GEORGIA INSTITUTE OF TECHNOLOGY
OFFICE OF CONTRACT ADMINISTRATION
SPONSORED PROJECT INITIATION

Date: October 14, 1976

Project Title: Utilization/Evaluation of AID Hand Pump

Project No: A-1894

Project Director: Phillip W. Potts

Sponsor: Agency for International Development

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3/31/81

Agreement Period: From September 1, 1976 Until October 30, 1978

Type Agreement: Contract No. AID/ta-C-1354

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Technical Matters

Office of Health (TA/H)
Bureau for Technical Assistance
Agency for International Development
Washington, DC 20523

Contractual Matters
(thru OCA)
Mr. Morton Darvin, Contracting Officer
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Washington, DC 20523

Defense Priority Rating:

Assigned to: Economic Development Laboratory (School/Laboratory)

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CA-3 (3/76)

GEORGIA INSTITUTE OF TECHNOLOGY OFFICE OF CONTRACT ADMINISTRATION

SPONSORED PROJECT TERMINATION SHEET

Date 1/7/82

Project Title: Utilization/Evaluation of AID Hand Pump

Project No: A-1894

Project Director: Phillip W. Potts

Sponsor: Agency for International Development

Effective Termination Date: 3/31/81

Clearance of Accounting Charges: 3/31/81

Grant/Contract Closeout Actions Remaining:

- [x] Final Invoice and Closing Documents
- [ ] Final Fiscal Report
- [ ] Final Report of Inventions
- [ ] Govt. Property Inventory & Related Certificate
- [ ] Classified Material Certificate
- [ ] Other ____________

Assigned to: TAL/IPO (School/Laboratory)

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FORM OCA 10:781

Project A-1894

WATER QUALITY/QUANTITY
IN
COSTA RICA AND NICARAGUA

Prepared for the
U.S. Agency for International Development

by
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Economic Development Laboratory
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Georgia Institute of Technology
April 1977

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Summary

In September 1976, the Engineering Experiment Station, Georgia Institute of Technology entered into an agreement with the Agency for International Development to evaluate (1) the performance and acceptability of a hand-operated water pump, previously designed for AID, in comparison with other pumps used in developing countries, and (2) the feasibility of local manufacture of the AID pump. Representative sites chosen for installation of both the AID pump and locally-available pumps show an average usage of approximately 75 persons in Costa Rica, and 150 persons in Nicaragua. In Costa Rica, most communities of 250 inhabitants or more have some form of piped water system, while in Nicaragua the size of the community will usually exceed 2,000 inhabitants before piped water is found. In Costa Rica, most communities will have at least one well with a pump, if not piped water, while in Nicaragua, springs, rivers, and open dug wells are the common sources of water. Costa Rica has a greater degree of electrification in rural areas, allowing the installation of motorized pumping systems that are not possible in many areas of Nicaragua. Further, the Ministry of Health in Costa Rica has had a hand-pump program for some fifteen years, while Nicaragua is just now in the beginning stages of such a program.

Water chemical and bacteriological tests for the two countries were performed, and are still being performed, to measure the beneficial changes resulting from the introduction of the water programs into the two countries of Costa Rica and Nicaragua. Chemical tests do not show results of great concern, but the bacteriological data show that all sites are contaminated with common intestinal bacteria. In Nicaragua, at Los Laureles (Site No. 12), Salmonella was discovered and merits further analysis to determine if any significant hazard exists. Because all sites showed bacterial contamination to some extent, even in Costa Rica where all sites had previously been disinfected and were equipped with hand pumps, bacterial testing will be carried out periodically during the remainder of the program to ascertain the true value of water pumps in relation to health.

INTRODUCTION

In September 1976, the Engineering Experiment Station, Georgia Institute of Technology (Georgia Tech) entered into an agreement with the Agency for International Development (AID) to evaluate (1) the performance and acceptability of a hand-operated water pump, previously designed for AID, in comparison with other pumps used in developing countries, and (2) the feasibility of local manufacture of the AID pump. This program, still under way, involves Georgia Tech in planning, installing, monitoring, and reporting upon a field test of the AID pump in Costa Rica and Nicaragua, using a counterpart organization, the Central American Research Institute for Industry (ICAITI, El Instituto Centroamericano de Investigacion y Tecnologia Industrial).

Organizationally, Georgia Tech has overall responsibility for the AID water-pump field testing. Members of the Engineering Experiment Station have been, and are currently, involved in national and international programs of community and area development, management and technical assistance to business and industrial firms, industrial and economic development training, market analyses, studies of new manufacturing opportunities, manpower resources and labor productivity, stimulation of small-scale industry, technology assessment, development and conservation of energy resources, housing resources, industrial economics, economic uses of industrial wastes, adaptive technology research and development, audiovisual presentations and multimedia documentation, and professional guidance in planning industrial and economic development programs.

ICAITI, chosen as a Central American counterpart to enable efficient utilization of travel funds and to take full advantage of its established working relationships with existing communities, industries, lending institutions, and governmental departments of Costa Rica and Nicaragua, is very similar to the Engineering Experiment Station. For more than 14 years, ICAITI has made significant contributions to the industrial development of Central America and has also completed a considerable number of related projects that are aiding in the success of this program.

The program, more specifically, consists of participation by Georgia Tech and ICAITI in the following activities:

1. Providing technical assistance for selected foundries and machine shops to locally manufacture the AID pump.

2. Selecting 60 field-test sites for installation of 30 AID pumps and 30 locally-available pumps.

3. Well drilling or rehabilitation of existing wells, as necessary.

4. Installation of pumps.

5. Monitoring of pump performance for a 12-month period.

6. Collection and analysis of field data.

Also included in the Georgia Tech/ICAITI program is this report on the quality and quantity of water available to the rural inhabitants of Costa Rica and Nicaragua, to be subsequently used to measure the beneficial changes resulting from the introduction of the water pump program into the two countries. The suitability of the water supply from the installed pumps has been, and will continue to be, determined by four types of analysis:

1. Chemical analysis to determine total solids, hardness, etc., to detect any harmful chemical ingredients, such as poisonous lead or zinc salts.

2. Physical examinations to determine if the water has any objectionable color, taste, or odor.

3. Biological analysis to detect algae, fungi, protozoa, nematode worms, the smaller species of crustacea, and the larvae of aquatic insects.

4. Bacteriological analysis, the most valuable and vital examination, to detect coliforms, Salmonella, Shigella, etc.

Emphasis in this report is put on the first (chemical) and the fourth (bacteriological) types of analysis because of their relative importance. In respect to the second and third types of analysis, physical examination has shown that almost all locations for pump testing have some objectionable characteristics such as trash, insects, etc., but much of this will be eliminated as the wells are cleaned out, disinfected, and pumps installed.

COSTA RICA

It is universally accepted that an adequate supply of water for drinking, personal hygiene, and other domestic purposes, and an adequate means of waste disposal are essential to public health and well-being. Unfortunately, vast numbers of people in the developing world, most of them living in rural areas, do not have access to a safe and convenient source of water. When safe and convenient sources are available, satisfactory sewage disposal facilities normally are still unavailable.[1/]

One aspect that has been obvious from the beginning of this project is that, even though Costa Rica is a developing country, it is much more developed than Nicaragua, and this shows up in the availability of potable water supplies for the two countries. For instance, based on a preliminary survey, representative test sites chosen for this project show an average usage of approximately 75 persons in Costa Rica, and 150 persons in Nicaragua. In Costa Rica, most communities of 250 inhabitants or more have some form of piped water system, while in Nicaragua the size of the community will usually exceed 2,000 inhabitants before piped water is found. In Costa Rica, most communities will have at least one well with a pump, if not piped water, and in Nicaragua, springs, rivers, and open dug wells are the common sources of water. Costa Rica has a greater degree of electrification in rural areas, allowing the installation of motorized pumping systems that are not possible in many areas of Nicaragua. Further, the Ministry of Health in Costa Rica has had a hand pump water program for some fifteen years, while Nicaragua is just now in the beginning stages of such a program.

This does not mean that Costa Rica is without a need for improvement in its potable water delivery system. The Ministry of Health, for instance, estimates that, at the present time, as many as 47,000 hand-operated water pumps are needed to provide a suitable water supply to the country's rural citizens.

Selection of Field Test Sites

Costa Rica was chosen as a test country because of a sizable loan that has been made to that country by the Agency for International Development.

1/ Robert J. Saunders and Jeremy J. Warford, Village Water Supply, (Baltimore, MD: The Johns-Hopkins University Press, 1976), p. 3.

Provisions of the loan specifically include installation of water pumps on a large-scale basis, and it is felt that using Costa Rica as a test country will enable that country to get a better start on its own program. Costa Rican Ministry of Health and Agency for International Development officials also strongly feel that local manufacturing offered by the Georgia Tech/ICAITI program has many advantages that should be included in the Costa Rican loan program (mainly employment generation and spare parts availability).

Table 1 shows those sites selected for the field testing which were chosen primarily because of their relative high usage and accessibility. All sites have existing, dug wells, equally divided between deep wells (as used herein, more than 22 feet in depth) and shallow wells. Selection was made during the dry season months of January, February, and March so the water column figures indicate annual low water levels (in some instances, the water level is unknown because the wells are sealed). The average well is used by 75 persons and already has an existing pump, with the condition of the pump varying from broken and inoperable to good. The last column of Table 1 is the type of pump that will replace the existing pump for field-testing purposes. The general areas of site concentration are in the northwestern quadrant of Costa Rica around Nicoya, Santa Cruz, Liberia, and Las Canas, and the eastern area of Limon (see Map 1).

Water Quality

A chemical analysis is available at the present time from only one site (No. 3), and it is obviously not possible to draw any general conclusions from such limited data. Nevertheless, it is informative to compare these results with the standards prescribed by the United States Public Health Service for drinking water:

	Reported	USPHS Standard
pH	6.9	--
Hardness	199.0 ppm $CaCO_3$	--
Iron	1.4 ppm	0.30 ppm
Manganese	0.0 ppm	0.05 ppm
Sulfate	8.0 ppm	250.00 ppm
Nitrate	0.6 ppm	45.00 ppm

Table 1

SELECTED SITES FOR AID PUMP FIELD TESTS IN COSTA RICA

Site No.	Location	Well Situation	Well Type	Classification by Depth	Depth to Water (mt.)	Depth to Water (ft.)	Water Column (mt.)	Estimated Usage - No. Persons 30-60	61-100	>100	Type of Existing Pump	Condition of Existing Pump	Type of Pump to Install[3]
1	Margarita (schoolhouse)	Existing	Dug	Shallow	2.30	7½	1.70		X		None	--	AID-SW
2	Bristol (Square No. 1)	Existing	Dug	Shallow	2.20	7	0.90		X		None	--	Japanese
3	Bristol (Square No. 2)	Existing	Dug	Deep[1]	--	--	--			X	Dempster	Good	Dempster
4	Baltimor	Existing	Dug	Shallow	3.20	10	1.00	X			None	--	AID-SW
5	Corina	Existing	Dug	Shallow[2]	--	--	--	X			Japanese	Poor	AID-SW
6	Corina (schoolhouse)	Existing	Dug	Deep	7.60	25	1.00		X		Dempster	Good	Dempster
7	Zent (Sr. Pedro Bustos)	Existing	Dug	Shallow	2.60	8½	1.60	X			None	--	AID-SW
8	Zent (Sr. Mariano Grijado)	Existing	Dug	Shallow	2.95	9½	1.85	X			None	--	Japanese
9	Zent (schoolhouse)	Existing	Dug	Shallow	3.30	11	1.60	X			None	--	AID-SW
10	El Brillante	Existing	Dug	Deep[1]	--	--	--		X		Dempster	Fair	AID-DW
11	Judas de Chomes	Existing	Dug	Shallow	5.70	19	4.10		X		Dempster[4]	Poor	Japanese
12	La Palma de Abangares	Existing	Dug	Deep	11.00	36	0.75		X		Japanese	Broken	AID-DW
13	San Joaquin de Abangares	Existing	Dug	Deep	10.30	34	1.40	X			Dempster	Poor	AID-DW
14	Pueblo Nuevo de Abangares	Existing	Dug	Shallow	5.20	17	1.40	X			Dempster	Fair	Japanese
15	San Buena Ventura de Colorado	Existing	Dug	Deep	7.00	23	2.70		X		Dempster	Good	Dempster
16	Penas Blancas de Colorado	Existing	Dug	Shallow	5.95	19½	1.55		X		Dempster	Good	AID-SW
17	Nicoya (Barrio San Martin)	Existing	Dug	Deep[1]	--	--	--	X			Dempster	Good	Dempster
18	Curime de Nicoya	Existing	Dug	Deep[1]	--	--	--	X			Dempster[4]	Poor	Dempster
19	Caimitalito de Nicoya	Existing	Dug	Deep	8.95	29	1.60	X			Red Jacket	Broken	AID-DW
20	Conjunto IMAS, El Torito, Samara	Existing	Dug	Shallow[2]	--	--	--			X	Dempster	Good	Japanese
21	Terciopelo de Nicoya	Existing	Dug	Deep[1]	--	--	--	X			Dempster	Poor	AID-DW
22	San Francisco de Santa Cruz	Existing	Dug	Deep	8.20	27	1.10	X			Dempster	Fair	Dempster
23	Hernandez de Santa Cruz	Existing	Dug	Shallow	2.45	8	1.85		X		Dempster	Good	Japanese
24	Villa Real de Santa Cruz No. 1	Existing	Dug	Deep[1]	--	--	--		X		Japanese	Poor	AID-DW
25	Villa Real de Santa Cruz No. 2	Existing	Dug	Deep	11.00	36	--		X		Dempster	Poor	Dempster
26	Villa Real de Santa Cruz No. 3	Existing	Dug	Deep[1]	--	--	--			X	Dempster	Fair	AID-DW
27	Los Pargos de Santa Cruz	Existing	Dug	Shallow	5.85	19	0.70	X			Dempster	Good	AID-SW
28	San Jose de Pinilla	Existing	Dug	Shallow	2.55	8	2.00			X	Dempster	Good	Japanese
29	Pijije de Bagaces	Existing	Dug	Deep	10.90	36	--	X			Dempster[4]	Good	Dempster
30	La Jarilla de Canas	Existing	Dug	Deep[1]	--	--	--	X			Dempster	Poor	AID-DW

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[1] Assumed deep: well sealed, depth unknown.

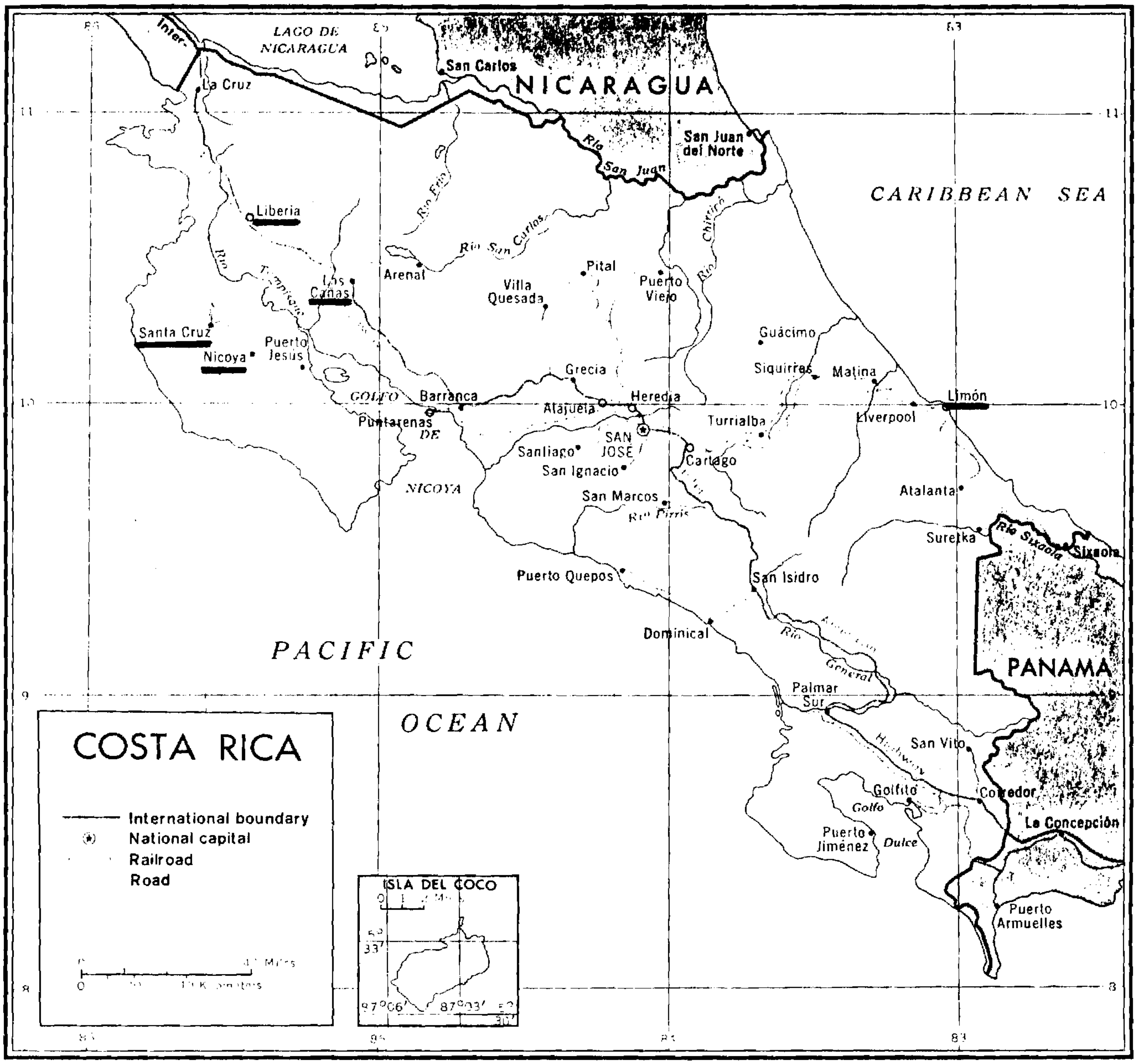
[2] Assumed shallow: well sealed, depth unknown.

[3] AID-DW: AID pump for deep well; AID-SW: AID pump for shallow well; Dempster: Dempster deep well type pump; Japanese: Japanese made shallow well type pump.

[4] Pump being used for forced pumping to storage tank.

Map 1

COSTA RICA



Sites in Costa Rica are concentrated in two major areas: (1) the northwestern quadrant around Nicoya, Santa Cruz, Liberia, and Las Canas, and (2) the eastern area of Limon.

The water represented by the sample is quite hard but is within the USPHS limits on all items except iron. While the high iron is not a desirable condition, it is not a source of great concern as it is objectionable only from the standpoint of taste and, possibly, staining of laundry. No toxicological significance would be expected.

Bacteriological samples from seven locations have been analyzed and all contain Escherichia coli in concentration ranging from 3.6 to 1,100 per 100 ml sample:

Site No.	Total Coliforms 35°C	Escherichia Coliform 44°C
11	210	150.0
12	1,100	460.0
13	460	21.0
14	1,100	290.0
15	460	240.0
16	1,100	1,100.0
30	93	3.6

Inasmuch as the presence of E. coli indicates fecal contamination, ideally none should be present. It is not surprising to find this existing condition, however, due to the circumstances of the individual wells themselves. While the wells were properly disinfected at the time of their construction, imperfect sealing of the top, seepage of surface water, and other conditions have lead to subsequent contamination. Bacteriological quality is subject to considerable variability, and frequent analysis of each site would be required to provide definite data. It is indicative, on the other hand, that there has not been a single location that was free of coliforms.

Water disinfection has been a routine matter in Costa Rica prior to installation of pumps, but there has been no laboratory analysis to reveal the extent of assumed contamination in the wells. It is hoped, and expected, that this program will show the importance of such analysis since testing of water will continue at each site until all sites have been thoroughly analyzed. Because many of the sites in Costa Rica have been disinfected in the past and the wells were supposedly sealed off from contamination, only to result in continued contamination, the sites will also be tested periodically after pump installation to measure the effectiveness of pump programs such as are now being carried out in both Costa Rica and Nicaragua. In other words, if wells with hand-operated pumps installed only have the advantage of an easier delivery system without an improvement in the quality of the water, the expenditures hardly seem justifiable. Obviously, public health education will almost always be necessary to achieve full health benefits.

NICARAGUA

Data from 1971 show that 53% of the total population of Nicaragua has relatively easy access to piped water supplies; however, when this figure is broken down into urban and rural areas, it is seen that 91% of the urban population has easy access to this type of water system, while only 18% of the rural population has easy access. Comparative figures for Costa Rica are 78% (total), 100% (urban), and 56% (rural). While these figures are somewhat outdated, it is felt that they probably have not changed drastically in the last six years.2/

Selection of Field Test Sites

Nicaragua was chosen as a test country for this program also because of a loan by the Agency for International Development, involving the installation of hand-operated water pumps. The loan provisions include a potable water program which will construct 300-340 wells in the next three years and which, as in the case of Costa Rica, the Georgia Tech/ICAITI program will complement, allowing the Ministry of Health of Nicaragua to take advantage of local manufacturing and all of its benefits.

Table 2 shows the sites selected for field testing in Nicaragua. Most of the wells are already existing, dug (there is one spring and one drilled well), and equally divided between deep wells and shallow wells. The depth to the water is not known in several cases because the wells are either dry (and will have to be deepened), or the wells are still under construction. Usage is quite high for the sites, averaging 150 persons, and all wells require site work of some kind (well deepened, lining applied to the well, slab and other concrete work performed, and/or the cleaning and disinfecting of the well). The only well with an existing pump is at Los Canas; however, this pump has obviously been inoperable for many years, and the well is of no value until it is cleaned out, disinfected, and a new pump installed. All sites in Nicaragua are concentrated in the northern part of the country, near Matagalpa and Esteli (see Map 2).

2/ The Dynamics of Health, XI: Nicaragua, published by the U.S. Department of Health, Education, and Welfare, 1973.

Table 2

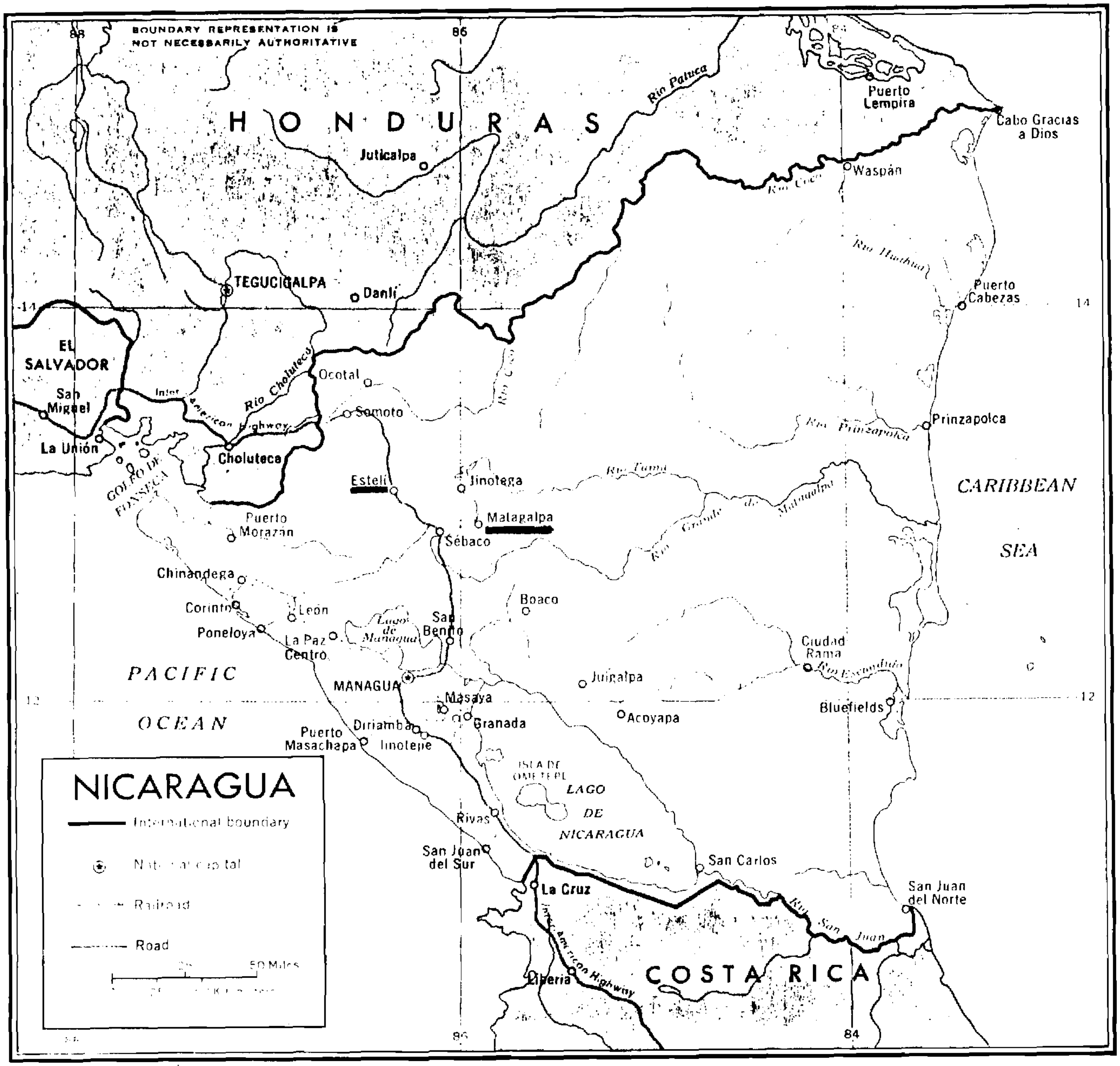
SELECTED SITES FOR AID PUMP FIELD TESTS IN NICARAGUA

Site No.	Location	Well Situation	Well Type	Classification by Depth	Depth to Water (mt.)	Depth to Water (ft.)	Water Column (mt.)	Well Diameter (mt.)	Estimated Usage (No. Persons) 50-100	Estimated Usage (No. Persons) 101-150	Estimated Usage (No. Persons) >150	Site Work Required: New Well	Site Work Required: Deepen Well	Site Work Required: Lining	Site Work Required: Slab	Site Work Required: Disinfect	Site Work Required: Install Pump	Type of Pump to Install[1]
1	La Garita (schoolhouse)	Existing	Dug	Deep	8.20	27	0.78	0.80	X				X		X	X	X	AID-DW
2	La Garita (highway)	New well required	Dug	Deep	--	--	--	--			X	X		X	X	X	X	Dempster
3	Llano Grande	Existing	Dug	Shallow	2.20	7½	1.77	1.20		X			X		X	X	X	AID-SW
4	Los Canas (highway)	Existing	Drilled	Deep	7.47	25	7.82	(6")		X						X	X	AID-DW
5	Los Canas (school)	Existing	Dug	Shallow	6.40	21	0.50	1.80	X				X		X	X	X	Braz.
6	Mechapa	Existing	Dug	Deep	17.80	58	0.95	1.23		X			X			X	X	Dempster
7	Las Lajitas	Existing	Dug	Shallow	5.40	18	0.45	1.45	X				X		X	X	X	AID-SW
8	San Lorenzo	Under construction	Dug	Deep	--	--	--	--	X				X	X	X	X	X	AID-DW
9	El Naranjo	Existing	Spring	Shallow	2.12	7	1.00	2.0x2.0			X		X		X	X	X	Braz.
10	Isidrillo	Existing	Dug	Deep	24.10	79	2.00	1.20			X		X			X	X	AID-DW
11	Rio Abajo (Santa Teresa)	Existing	Dug	Shallow	3.50	11½	0.85	1.2x1.2			X		X			X	X	Braz.
12	Rio Abajo (Los Laureles)	Existing	Dug	Shallow	4.08	13	0.34	1.2x1.2		X			X			X	X	AID-SW
13	Quebrada Arriba	New well required	Dug	Shallow	--	--	--	--			X	X		X	X	X	X	Braz.
14	Los Rincones	Existing	Dug	Deep	19.20	63	1.00	1.20			X		X			X	X	AID-DW
15	Rio Grande	New well required	Dug	Shallow	--	--	--	--		X		X		X	X	X	X	Braz.
16	San Antonio	Existing	Dug	Deep	9.87	32	0.55	0.70			X		X	X	X	X	X	AID-DW
17	El Rodeo	Existing	Dug	Deep	15.91	52	0.33	1.20	X				X		X	X	X	Dempster
18	Los Calpules (stream)	Existing	Dug	Shallow	1.37	4½	1.18	1.20	X				X		X	X	X	AID-SW
19	Los Calpules (schoolhouse)	Existing	Dug	Deep	8.45	28	0.51	1.20			X		X		X	X	X	Dempster
20	Motolin (Sr. Umanzor)	Existing	Dug	Deep	15.56	41	0.42	1.00		X			X		X	X	X	Dempster
21	Ducuale Grande	New well required	Dug	Shallow	--	--	--	--		X		X		X	X	X	X	AID-SW
22	La Concepcion (No. 1)	Existing	Dug	Deep	--	--	--	--	X				X		X	X	X	Dempster
23	Valle Santa Rosa	Under construction	Dug	Deep	--	--	--	--		X			X	X	X	X	X	AID-DW
24	Sabana Grande	Existing	Dug	Deep	14.17	46½	0.23	0.91	X				X		X	X	X	AID-DW
25	San Diego	Existing	Dug	Deep	27.48	90	0.20	1.17		X			X			X	X	Dempster
26	La Concepcion (No. 2)	Existing	Dug	Shallow	--	--	--	--	X				X		X	X	X	AID-SW
27	Valle Santa Lucia	Under construction	Dug	Shallow	--	--	--	--			X		X	X	X	X	X	AID-SW
28	Los Curritos	New well required	Dug	Shallow	--	--	--	--		X		X		X	X	X	X	Braz.
29	Las Mangas	Existing	Dug	Deep	8.76	29	5.90	1.09			X				X	X	X	Dempster
30	La Majadita	Existing	Dug	Shallow	6.15	20	0.80	1.00	X				X		X	X	X	Braz.

[1]AID-DW: AID pump for deep well; AID-SW: AID pump for shallow well: Dempster: Dempster deep well type pump; Braz.: Brazilian shallow well type.

Map 2

NICARAGUA



Sites in Nicaragua are concentrated in the northern part of the country, near Matagalpa and Esteli.

Water Quality

The results of chemical analysis of 15 sites are given in Table 3. For comparison, the limits established by the USPHS for drinking water are also included. In general, the water sampled is quite hard. Los Rincones (Site No. 14) is given as a hardness of 70, but this may be in error if the total solids content of the water (608 mg/l) is correct. The total solids content of all other samples is in an acceptable range. Iron content is low in every case, and manganese was found in only four samples. (Las Lajitas, Site No. 7, is the only location where manganese might be a significant problem from its tendency to stain laundry.)

Nitrate levels are low with the single exception of Isidrillo (Site No. 10) where the reported nitrate level of 306.5 mg/l exceeds the 100 mg/l total solids. It appears likely that a clerical error has occurred, and the nitrate value was probably intended to be 30.65 mg/l. The levels of fluoride present may offer considerable resistance to tooth decay, as the recommended concentration in the United States where water supplies are to be fluoridated are 0.7-1.2 mg/l, depending on the air temperature. Both chloride and sulfate are at sufficiently low concentrations.

An examination of the bacteriological data (Table 4) shows that all sites are significantly contaminated with common intestinal bacteria. The positive finding of Salmonella at Los Laureles (Site No. 12) is cause for special concern, and additional samples from this site will be analyzed to determine if any significant hazard is present.

Table 3

SUMMARY OF WATER CHEMICAL ANALYSES[a] -- NICARAGUA

Site No.	Location	pH	Hardness as $CaCO_3$	Alkalinity as HCO_3^-	Total Solids	Fe	Mn	Ca	NO_3^-	F	Cl	$SO_4^=$
1	La Garita	7.0	350	26	218	0.07	0.05	70.0	3.76	0.30	22.5	2.0
3	Llano Grande	6.4	200	120	161	0.07	0.00	30.0	9.96	0.70	12.5	3.0
6	Mechapa	7.7	325	30	330	0.06	0.00	80.0	13.10	0.40	12.5	8.0
7	Las Lajitas	7.5	200	190	225	0.02	0.40	50.0	4.43	0.35	5.0	2.0
9	El Naranjo	6.9	400	420	426	0.05	0.00	100.1	3.54	0.70	15.0	3.0
10	Isidrillo	7.6	400	180	100	0.07	0.00	90.0	306.50	0.35	62.5	10.0
11	Santa Teresa	8.1	240	265	383	0.01	0.00	62.0	9.52	0.35	15.5	11.0
12	Los Laureles	7.7	250	265	340	0.01	0.00	64.0	6.42	0.60	15.0	6.0
14	Los Rincones	8.1	70	445	608	0.01	0.00	20.0	16.60	0.25	20.0	20.0
16	San Antonio	7.9	240	270	404	0.01	0.00	68.0	2.65	0.50	19.5	11.0
18	Los Calpules	7.9	290	330	394	0.01	0.10	80.0	0.00	0.55	10.0	2.0
19	Los Calpules	7.9	210	200	237	0.01	0.00	50.0	5.10	0.60	12.5	4.0
20	Motolin	8.2	240	250	298	0.05	0.00	62.0	22.40	0.65	14.0	4.0
22	La Concepcion	7.5	350	30	264	0.00	0.10	80.0	0.00	0.40	10.0	3.0
29	Las Mangas	6.4	100	100	38	0.02	0.00	20.0	2.21	0.50	15.0	2.0
	Drinking Water Standards USPHS	--	--	--	500	0.30	0.05	--	45.00	(b)	250.0	250.0

(a) All values mg/l except pH.

(b) Limit depends on daily air temperature. Upper limits range from 0.8 to 1.7 mg/l.

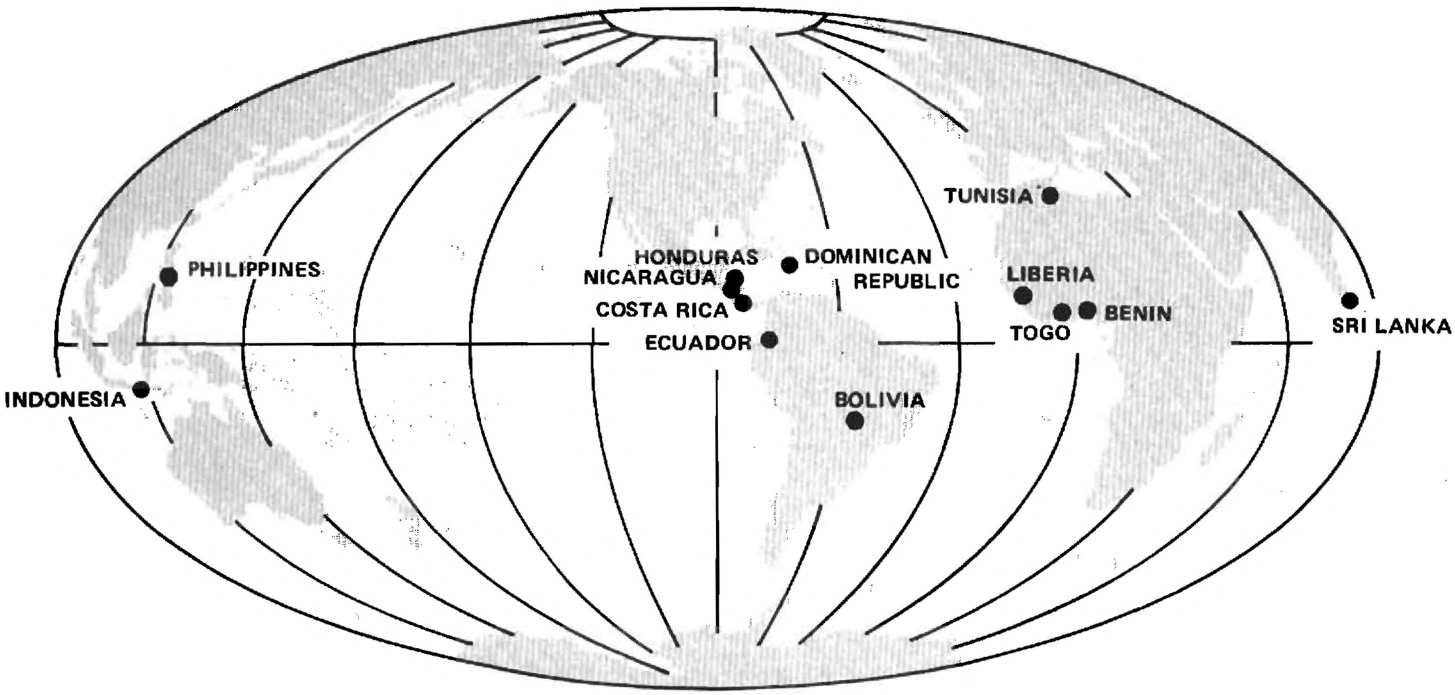
Table 4

SUMMARY OF BACTERIOLOGICAL ANALYSIS -- NICARAGUA

Site No.	Location	Coliforms per 100 ml	Salmonella Presence	Shigella Presence	Comments
1	La Garita	2.4	Negative	Negative	Positive Enterobacter
3	Llano Grande	430.0	Negative	Negative	Positive Enterobacter and Citrobacter
6	Mechapa	1,100.0	Negative	Negative	Positive Proteus and Citrobacter
7	Las Lajitas	150.0	Negative	Negative	Positive Enterobacter
9	El Naranjo	1,100.0	Negative	Negative	Positive Enterobacter
10	Isidrillo	1,100.0	Negative	Negative	None
11	Rio Abajo (Santa Teresa)	24.0	Negative	Negative	Positive Enterobacter
12	Rio Abajo (Los Laureles)	64.0	Positive	Negative	Positive Salmonella sp, Enterobacter, and Citrobacter
14	Los Rincones	54.0	Negative	Negative	Positive Pseudomonas
22	La Concepcion	2.4	Negative	Negative	Positive Pseudomonas
25	San Diego	2.4	--	--	No samples analyzed for Salmonella and Shigella
29	Las Mangas	81.0	Negative	Negative	Positive Escherichia coli polivalente A

A-1894

THE AID HAND-OPERATED WATER PUMP:



A CLASSIC EXAMPLE OF TECHNOLOGY TRANSFER

GEORGIA INSTITUTE OF TECHNOLOGY
ATLANTA, GEORGIA 30332

THE AID HAND-OPERATED WATER PUMP: A CLASSIC EXAMPLE OF TECHNOLOGY TRANSFER

Prepared for

The United States Agency for International Development
under Contract No. AID/ta-C-1354

by

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EXECUTIVE SUMMARY

In September 1976, the Georgia Institute of Technology (Georgia Tech) was contracted by the Agency for International Development (AID) to select two developing countries for local manufacturing and field testing of the AID hand-operated water pump. The scope of work included technical assistance to foundries and machine shops in the manufacturing operation and evaluating the performance and acceptability of the hand pump when heavily used.

Nicaragua and Costa Rica were chosen as initial test countries based on several factors including the existence of adequate manufacturing capabilities, upcoming hand pump programs planned by AID in collaboration with the Ministry of Health in both countries, and enthusiasm about the project goals and the resulting development spin-offs. Local manufacture of the AID hand pump was completed and field trials initiated between January 1977 and September 1979. The AID pump was subsequently determined to be reliable, sturdy, easily maintained, low in cost compared to imports, and capable of being manufactured in developing countries. As a result of the Nicaraguan and Costa Rican field tests, minor design modifications were recommended that proved successful in later field tests.

An assessment was then made of existing manufacturing capabilities for the Dominican Republic and a market analysis performed to determine the relative cost of local manufacturing versus importing. The AID hand pump was found to be appropriate, and in August 1978 Georgia Tech was contracted to help develop local manufacturing capabilities and conduct field tests. Even though a prototype available from Nicaragua provided guidance in fabricating the AID hand pump in the Dominican Republic, the first batch of finished pumps clearly showed difficulty in adhering to specified tolerances. However, of the 24 test pumps manufactured, 21 were installed and functioned well. These initial manufacturing problems were resolved through technical assistance, and the Dominican Republic has officially accepted the AID hand pump for its own use.

An AID hand pump program began in Indonesia in early 1978 with Georgia Tech personnel performing a manufacturing feasibility study, and based on initial findings an AID/Georgia Tech contract was signed in September 1978. This contract required that Georgia Tech provide technical assistance in producing 230 AID hand pumps, install 60 of the pumps in six Provincial Development Program (PDP) areas with 35 of the pumps in the Bandung area, 10 in the Jakarta area, and 11 at

sanitarian schools, monitor the performance of the pumps and feed back data to the manufacturer for tightening of quality controls when defects appear, and assess the feasibility of manufacturing the pumps in three PDP areas. Prospects for wide use of the AID hand pump in Indonesia now appear promising as the Cooperative for American Relief Everywhere (CARE) has installed over 200 of these pumps for its own rural water supply programs. The Asian Development Bank (ADB) is also considering its use for 3,000 wells in the Sulawesi region. Other organizations are expected to use the pump as additional foundries are identified and exposed to the marketability of the pump. It is noteworthy that at one rural village where a test pump was installed, local residents took up a collection to purchase three additional pumps, developed well sites, and installed the pumps themselves. Such initiative is admirable and both Georgia Tech and AID are proud of fostering this type of accomplishment.

In October 1979, Georgia Tech personnel were asked to determine the feasibility of manufacturing the AID hand pump in Sri Lanka. In March 1980, a local manufacturing program began at a foundry and machine shop. The pumps produced thus far appear to be of excellent quality. By August 1981 the installation phase of the project should be completed, with a monitoring and evaluation period extending through December 1981. By the time the project is completed, the manufacturer should be capable of producing the pump at a high level of quality without external technical assistance and supplying national and international organizations on a large-scale basis.

In April 1980, a Georgia Tech team visited Tunisia to determine if the AID hand pump program would be suitable for the country. Surveys of Tunisian foundries, machine shops, plastics manufacturers, and retail hardware stores indicated that local manufacture of the pump was both technically and economically feasible as a viable alternative to expensive imports. In August 1980, a contract was signed between USAID/Tunisia and Georgia Tech to provide technical assistance related to local manufacture of the AID hand pump, evaluation of pump performance, and water quality improvement. In January 1981, a prototype pump of very good quality was produced and approval was given to proceed with the production of 40 pumps by April 1981.

The AID hand pump program was expanded to Ecuador in August 1980. Initial results indicated that a hand pump program would improve living conditions by providing safer, more convenient water, as well as stimulating industrial development and reducing foreign exchange requirements. Based on this information, a contract was signed between USAID/Ecuador and Georgia Tech in September 1980 to provide technical assistance in locally manufacturing AID hand pumps and assuring their applicability for introduction into bilateral health projects that include water supply components. Plans call for installing AID pumps in June 1981 in rural areas of Ecuador by CARE, the Peace Corps, Voz Andes Hospital's Community Development Department, the Ecuadorian Institute of Sanitary Works and the Center for the Rehabilitation of Manabi. Georgia Tech will perform training in site selection, well preparation, installation techniques, proper disinfection of water, bacteriological analysis of water, and maintenance and repair. These activities should result in national acceptance of the AID hand pump into future Ecuadorian rural water supply programs.

Honduras, the Philippines, Bolivia, Togo, Benin and Liberia have also been surveyed by Georgia Tech to determine if the AID hand pump is appropriate and can be manufactured at a competitive cost. Manufacturing, field testing, and pump performance monitoring and evaluation activities are expected to begin in Honduras and the Philippines soon because of positive results from the surveys and an interest on the part of the respective AID Missions and host country organizations in promoting the pump. Bolivia has already developed and accepted a World Bank-funded hand pump that is locally manufactured. Togo and Benin were not appropriate for the AID hand pump since most of the wells were too deep. Liberia did not have sufficient manufacturing capabilities to support a pump program.

Introducing the local manufacture of the AID hand pump in developing countries is a classic example of effective technology transfer. Georgia Tech has established a methodology for working with private sector manufacturers and government organizations to stimulate the local fabrication, installation, and use of the pumps as well as monitoring of water quality. This methodology is simple and easily applied in a variety of countries with a variety of devices other than hand pumps. However, much detailed work is involved in initiating the local manufacture of any product such as the AID hand pump. The manufacturer must be assisted in reaching a satisfactory level of quality control, and the implementing organizations must be made aware of the product capabilities and problems. Such a program requires patient, prolonged, and understanding work with personnel from private, government, and international organizations to share the knowledge and techniques of industrial nations through adaptation rather than duplication and procurement.

INTRODUCTION

The Georgia Institute of Technology is committed to the three major activities of teaching, research, and public service. Each of these activities has played a key role in responding to the needs of local, state, regional, national, and international communities for updating basic and advanced technical knowledge and skills. Thus, this publication has been prepared to describe a development activity related to rural water supply technology transfer serving the international community during the past five years. Georgia Tech is grateful to the Agency for International Development (AID), especially to officials of the Environmental Health Division, Office of Health, Development Support Bureau, Washington, D.C. for the opportunity of participating in this endeavor.

During the period from 1964 to 1975, AID contracted with the Battelle Memorial Institute to design a low cost, easily maintained hand-operated water pump that could be manufactured in developing contries. In September 1976, Georgia Tech was contracted by AID to select two developing countries for the local manufacture and field testing of this pump. The scope of work included technical assistance to foundries and machine shops in the manufacturing operation and evaluating the performance and acceptability of the pump when heavily used. Georgia Tech was chosen for these tasks because of its experience in stimulating small-scale industry in developing countries.

Nicaragua and Costa Rica were chosen as initial test countries because of:

- Adequate existing manufacturing capabilities
- Upcoming hand pump programs planned by AID in collaboration with each country's Ministry of Health
- Enthusiasm over the project goals and the resulting development spin-offs by the governments

Local manufacture of the AID hand pump was completed and field trials initiated between January 1977 and September 1979. The AID pump was subsequently determined to be reliable, sturdy, easily maintained, low in cost compared to imports, and able to be manufactured in developing countries. As a result of the Nicaraguan and Costa Rican field tests, minor design modifications were recommended that proved successful in later field tests.

Technology transfer programs have since begun in the Dominican Republic, Indonesia, Sri Lanka, Tunisia, and Ecuador. These hand pump programs represent the application of technology transfer in its most complete form to developing countries and have clearly indicated that further use of the AID hand pump should be encouraged. The pump can be manufactured in a developing country at a competitive, profitable price and at an acceptable level of quality if adequate facilities are available. However, the availability of adequate manufacturing facilities and sufficient market demand are factors that must be determined for each developing country. Acceptance by villagers has been excellent with regard to aesthetics, simplicity, and ease of use.

Several national and international agencies have adopted or are considering adoption of the AID hand pump for their own use. The organizations include:

- Ministry of Health in the Dominican Republic
- Ministry of Health in Nicaragua
- Voz Andes Hospital's Community Development Department in Ecuador
- Ministry of Health in Ecuador
- Peace Corps in Ecuador
- Cooperative for American Relief Everywhere (CARE)
  - Indonesia
  - Tunisia
  - Sri Lanka
  - Ecuador
- Asian Development Bank (ADB) in Indonesia
- Ministry of Industry in Indonesia
- Ministry of Health in Indonesia
- Ministry of Agriculture in Tunisia
- Ministry of Local Government, Housing and Construction in Sri Lanka
- United Nations Childrens Fund (UNICEF) in Sri Lanka

The AID hand pump program has had a positive impact on the rural health (though admittedly difficult to quantify), employment generation, spare parts availability, and foreign exchange requirements. In addition, national pride is instilled when local capabilities are used for manufacturing a relatively complicated product rather than importing. These impacts are extremely important in the development of a country, as recognized by AID Missions, and should never be underestimated. AID hand pump programs represent not just the single aspects of health improvement, rural development, urban development or capital development, but an integration of all of these objectives.

The following chapters give a general overview of the AID hand pump program and Georgia Tech's methodology for technology transfer. This methodology, if carefully followed, can serve as an operational model for the transfer of a wide variety of technologies ranging from hand pumps to solar-powered water systems, home water disinfection to large community water treatment, or manually operated drilling tools to large high-production drilling rigs. All of these programs would work to match university, public, and private sector expertise with host country needs and market demands.

Figure. 1

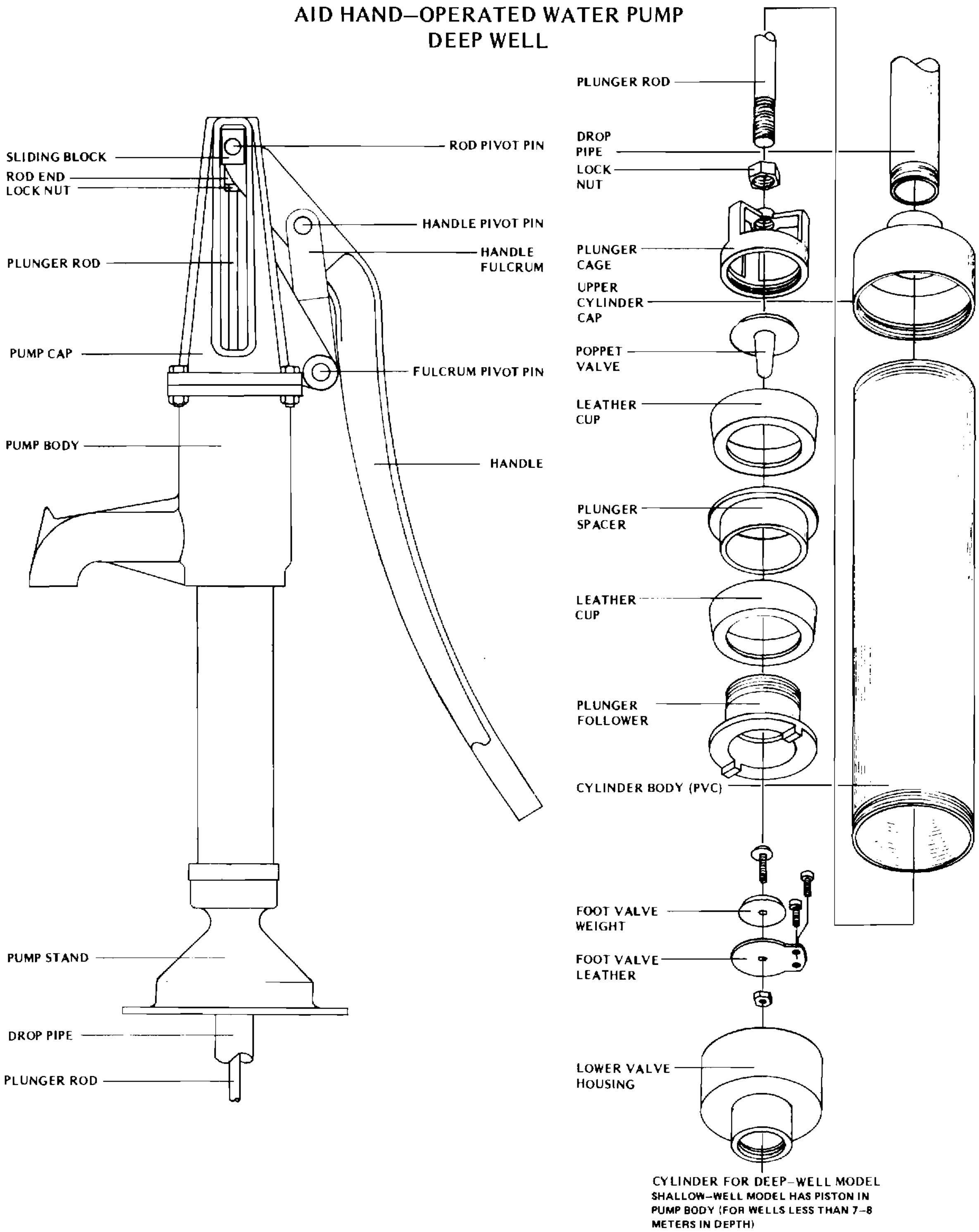
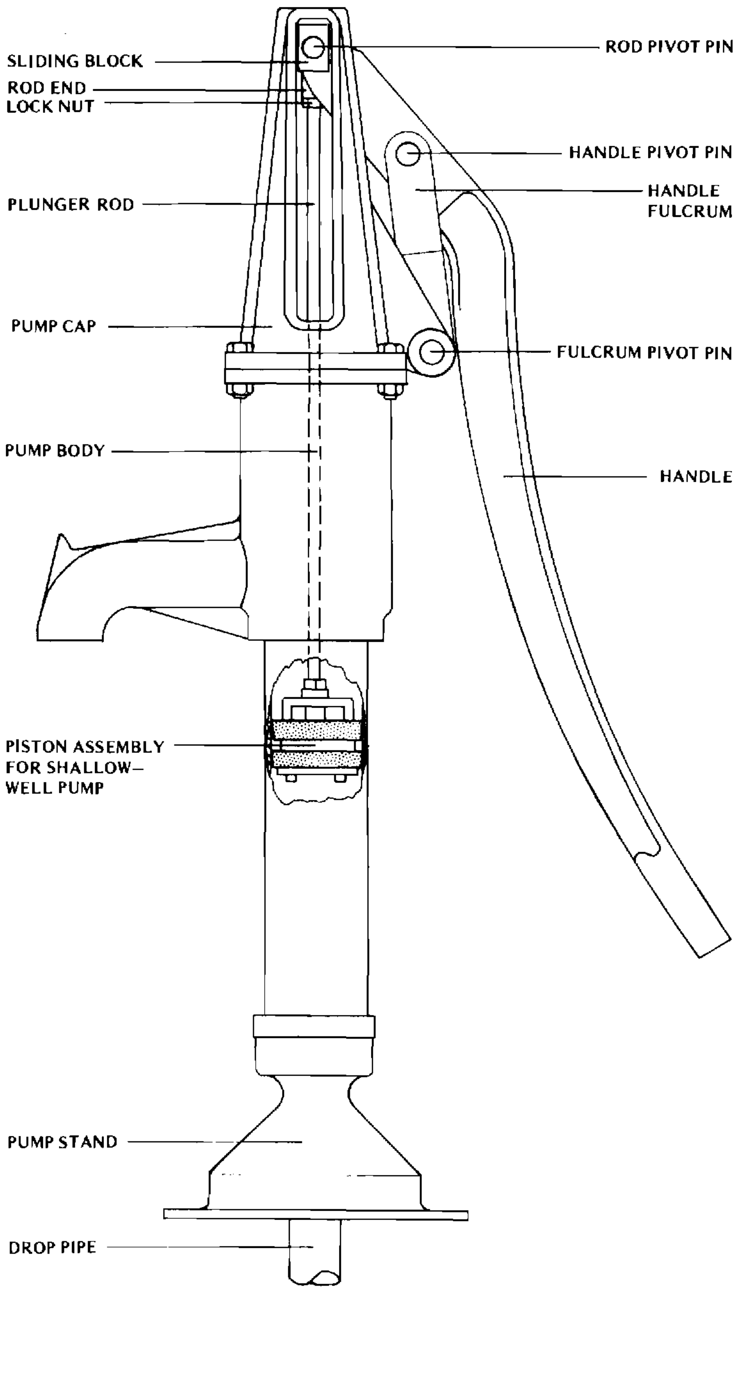

AID HAND–OPERATED WATER PUMP
DEEP WELL
SLIDING BLOCK
ROD END
LOCK NUT
PLUNGER ROD
PUMP CAP
PUMP BODY
PUMP STAND
DROP PIPE
PLUNGER ROD
ROD PIVOT PIN
HANDLE PIVOT PIN
HANDLE FULCRUM
FULCRUM PIVOT PIN
HANDLE
PLUNGER ROD
DROP PIPE
LOCK NUT
PLUNGER CAGE
UPPER CYLINDER CAP
POPPET VALVE
LEATHER CUP
PLUNGER SPACER
LEATHER CUP
PLUNGER FOLLOWER
CYLINDER BODY (PVC)
FOOT VALVE WEIGHT
FOOT VALVE LEATHER
LOWER VALVE HOUSING
CYLINDER FOR DEEP–WELL MODEL
SHALLOW–WELL MODEL HAS PISTON IN PUMP BODY (FOR WELLS LESS THAN 7–8 METERS IN DEPTH)

Figure. 2

AID HAND–OPERATED WATER PUMP
SHALLOW WELL

(For Wells less than 7-8 meters in depth)



NICARAGUA

Guatemala, El Salvador, Nicaragua and Costa Rica were visited by project personnel in the fall of 1976 to determine:

- o Existing manufacturing capabilities for producing the AID hand pump
- o Relative local manufacturing cost versus import costs
- o Applicability of the hand pump to rural water supply programs

All four countries were found to have sufficient manufacturing capabilities and the prices quoted for manufacturing the AID hand pump were much less than those for comparable imported hand pumps. Nicaragua and Costa Rica were chosen to be initial test countries because they also had upcoming AID-funded rural water supply programs that could utilize the AID pump. In addition, a high level of enthusiasm was exhibited by the AID Missions and each host country for such a test program.

Nicaragua had a rural water supply loan from AID that called for the installation of 300 hand pumps by the end of 1979. The AID/Georgia Tech program complemented this program by providing technical assistance in hand pump selection, installation techniques, repair, and maintenance. The program also enabled the Ministry of Health in Nicaragua to take advantage of locally manufactured hand pumps produced at a cost lower than commercially available imported pumps.

Program activities began in Nicaragua in January 1977 when a local foundry, Complejo Metalurgico Especializado, S.A. (COMETALES), was contracted to manufacture 20 AID hand pumps. The U.S. manufactured Dempster heavy duty Model 210F pump and a Brazilian Marumby pump were used for comparison since they were both locally available imports. A hand pump developed by the International Development Research Centre (IDRC) of Ottawa, Canada and the U.S. manufactured Moyno hand pump were also used for comparison. Unfortunately, the Moyno pump was added to the test program in the latter stages of the project and civil disorders prevented extensive monitoring of its performance. Thirty representative sites were selected to receive the initial test pumps installed by a Ministry of Health team with the Moyno pumps installed approximately a year after the rest. Immediately following installation, the wells were disinfected with a chlorine-yielding substance.

During the survey of manufacturing facilities in Nicaragua many foundries were identified but pattern makers, a very necessary requirement for local production, were practically nonexistent. One foundry was located that had all of the necessary resources, including pattern makers, to manufacture a quality hand pump. A contract was signed for the manufacture of eleven deep-well AID hand pumps (the plunger and the cylinder located below the well's water level when installed) and nine shallow-well AID hand pumps (the plunger and the cylinder located in the pump stand above ground). The prices for these pumps in 1977 were as follows:

Shallow-well model	\$69 each
Deep-well model	\$75 each
Patterns	\$1,000 (one-time charge only)

By comparison, in 1977 the Dempster hand pump cost \$257 delivered (pump, cylinder, and transportation), the Brazilian Marumby hand pump cost \$45 delivered, and the IDRC hand pump cost \$70, when fabricated in Nicaragua. The Moyno hand pumps cost \$400 each, plus packing and shipping, for an average total unit cost of \$470. The Moyno hand pump price of \$400 was actually a price for demonstration and advertising purposes reduced from \$800, and now sells for approximately \$500 per unit in lots of less than 100 pumps.

Two major manufacturing problems became apparent when the field tests began. First, the weakest point on the cap of the deep-well pump was where maximum stress was being applied by the handle fulcrum upon the pivot arm of the cap, thus causing the pivot arm to break off from the cap. Because of an indented contour on the top plate of the pump body, it was not possible to cast the pump body as specified by the design drawings since the patterns for the pump could not be removed from the molding sand without destroying the mold. Therefore, the manufacturer eliminated the indented contour on the top plate of the pump and then did not have enough clearance between the pivot arm of the cap and the top of the pump body. In order to obtain a better fit between the pump cap and the pump body, the manufacturer milled away a fillet on the pivot arm, leaving a notch at the point of maximum stress. To alleviate the entire problem, the pump cap was redesigned by lifting the pivot arm up and away from the pump body and positioning it so that it did not absorb as much of the stress caused by the downward force of the pump handle. The redesigned cap was put into production successfully at the manufacturer's foundry and installed on the pumps in the field, solving the initial problem.

The second major problem encountered with the AID hand pump in Nicaragua was a lack of three inch PVC pipe for the deep-well cylinders. As a result, the manufacturer used undersized PVC pipe and expanded it by heating. Quality control for such a process was very difficult and the results were unacceptable. While several of these PVC cylinders were installed in the field, it was decided that metal cylinders coated internally with epoxy would have to be used until the three inch PVC could be made available locally or imported from another country. In July 1977, the correct size PVC was obtained from a local manufacturer and acceptable cylinders were produced according to specifications. These new cylinders were far superior to both the epoxy-coated cylinders and the cylinder made by expanding the undersized pipe.

The majority of the manufacturing and quality control problems encountered were to be expected when a new product like the AID hand pump was introduced into local production for the first time. As subsequent orders were processed and personnel became more familiar with the pump, quality control was refined to the point where the orders were considered to be normal high quality production. Further, all design weaknesses were satisfactorily overcome as a result of modifications made by project personnel and ultimately proved to be workable in other developing country environments.

The hand pumps used for comparison were extremely valuable in providing performance data. The Dempster pumps performed well and gave no major problems. The IDRC pump performed relatively well, but had some difficulty with the foot valve sticking in the open position, as well as with consumer acceptance. The Moyno pump also performed well even though it's late inclusion into the test program provided only limited information.

The Marumby pump presented major problems. The handle and pump cap connection point was weak and in three of the five pumps tested, the pump cap had to be replaced due to breakage at this point. Spare parts were also difficult to find and the local distributor did not carry a large inventory of extra pumps for replacement purposes. This factor enhances the argument for locally manufacturing pumps so that spare parts can be made readily available.

The AID hand pump was chosen over the other pumps by the Nicaraguan Ministry of Health's PLANSAR (Planificacion de Sanitacion y Aquas Rurales) unit for its overall performance and benefits from local manufacture. In addition, the foundry (COMETALES) began regular production of the pump shortly before the AID/Georgia Tech program ended, thus displaying its ability to manufacture a quality hand pump without further external technical assistance. However, civil disorder erupted later that led to an overthrow of the existing government and the Ministry of Health's hand pump program was discontinued even though the foundry was still offering the pump as one of its products.

Despite the unfortunate series of events that led to the discontinuance of the use of the AID hand pump in Nicaragua, the AID/Georgia Tech program was very successful since it allowed project personnel to obtain field data resulting in refinement of the pump for local manufacture, installation, and operation/maintenance requirements in other countries.

FIGURE 3. AID DEEP-WELL MODEL HAND PUMP (NICARAGUA)

FIGURE 4. AID SHALLOW-WELL MODEL HAND PUMP (NICARAGUA)

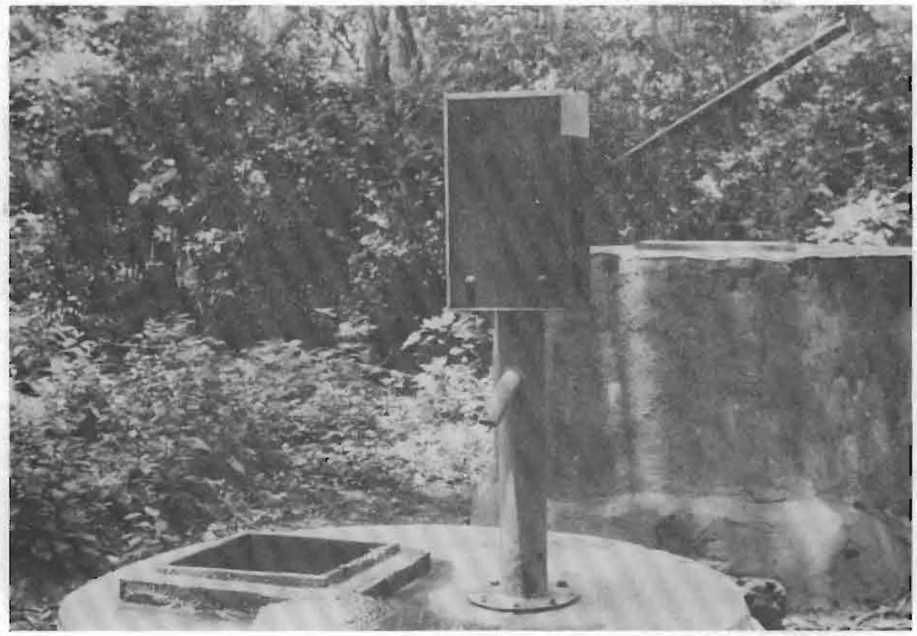


FIGURE 5. INTERNATIONAL DEVELOPMENT RESEARCH CENTRE HAND PUMP (NICARAGUA)

FIGURE 6. BRAZILIAN MARUMBY HAND PUMP (NICARAGUA)

FIGURE 7. UNITED STATES DEMPSTER HAND PUMP (NICARAGUA)

COSTA RICA

Costa Rica was chosen as a test country for evaluating the performance and acceptability of the AID hand pump because of a large well and hand pump program loan and because of the country's need and interest in a locally manufactured hand pump. Provisions of the loan specifically included installation of hand pumps on a large-scale basis and, as with Nicaragua, it was felt that a locally manufactured pump had many advantages that should be included in the Costa Rican loan program. These advantages included employment generation, spare parts availability, reduction of foreign exchange requirements, and lower cost than for commercially available imported hand pumps.

A machine shop, Mecanizados Mofama, S.A., which purchased rough iron castings from a local foundry, was contracted to manufacture 20 AID hand pumps. These pumps, eleven deep-well and nine shallow-well, were installed in April 1977. The Dempster and the Japanese Lucky pump were chosen for comparison. The test pumps were installed at 31 representative sites (16 AID hand pumps and 15 comparative pumps) and as in Nicaragua, the pumps were installed by Ministry of Health engineers and technicians. However, in Nicaragua most of the sites had to be completely developed whereas in Costa Rica, existing wells with inoperable pumps were used by merely replacing broken pumps with the test pumps.

A contract was signed with Mecanizados Mofama, S.A. in January 1977 for the manufacture of nine shallow-well pumps and eleven deep-well pumps. The prices of the AID pumps in 1977 were as follows:

Shallow-well model	\$ 98 each
Deep-well model	\$128 each
Patterns	\$498 (one-time charge only)

For comparison, the Dempster cost \$257 in 1977. The Lucky pump from Japan cost \$63 delivered.

Mecanizados Mofama, S.A. encountered several manufacturing problems while producing the AID hand pump. Most of these problems were related to the manufacturer's unfamiliarity with the pump and from poor castings. The foundry producing the castings had no laboratory facilities and used scrap iron as the source of raw materials. As a result, the pump castings produced were rough in texture, contained voids and inclusions, and would be considered unacceptable by U.S.

standards. However, subsequent castings produced for replacement parts showed a significant improvement as the foundry gained production experience. In addition, no replacement parts broke during a subsequent 12-month monitoring period under high use and a variety of field conditions.

In general, the functional performance and acceptance of the Costa Rican manufactured AID hand pump was satisfactory, but initial casting defects were encountered that necessitated the replacement of several handles, caps, and handle fulcrums. In all cases, these failures were caused by a lack of quality control at the foundry. Better foundries were available, but unfortunately none were interested in initial small orders, even though the potential for much larger orders existed.

The foundry also had difficulty in casting the deep-well pump cap as designed by Battelle and, as a result, proposed that the design be substituted with a less complicated cap similar to that used on Dempster hand pumps. The proposed design change was approved by project personnel, put into production, and field tested. the test results were acceptable but not as good as those of the modified Battelle design used in Nicaragua. The Costa Rican redesigned cap used a stuffing box as a piston rod guide that quickly wore out, while the Nicaraguan redesigned cap used sliding blocks that showed excellent resistance to abrasion caused by friction.

Even though Costa Rican Ministry of Health officials decided not to adopt the AID hand pump for future installations, they later made the decision to locally manufacture a hand pump that contained many of the features of the AID pump. For Georgia Tech and AID, field test results clearly highlighted the modifications necessary to make the AID pump acceptable in a developing country environment. These modifications were essentially to use the cap design modifications developed for Nicaragua on both deep-well and shallow-well models and to use a double-cup arrangement with the piston assembly for longer life of the cups and for a better seal.

FIGURE 8. AID DEEP-WELL MODEL HAND PUMP WITH CAP DESIGNED BY COSTA RICAN FOUNDRY

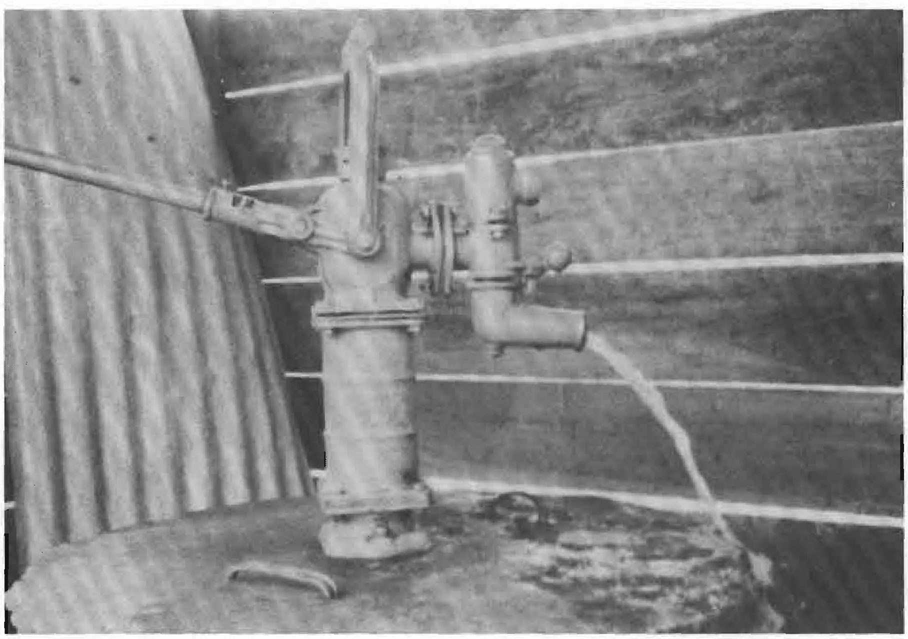


FIGURE 9. JAPANESE LUCKY HAND PUMP (COSTA RICA)

DOMINICAN REPUBLIC

An inspection and assessment of existing manufacturing capabilities, a market analysis, and determination of the relative cost of manufacturing the AID hand pump locally versus importing hand pumps preceded the introduction of the pump into the Dominican Republic. It was concluded that the AID hand pump was appropriate for the Dominican Republic, and in August 1978 Georgia Tech was contracted to develop local manufacturing capabilities and conduct field tests that would clearly show any manufacturing defects that needed to be corrected.

The interest by USAID/Dominican Republic and the Dominican Republic Ministry of Health was due to an upcoming AID health sector loan that included drilling wells and installing hand pumps in the western region of the country. Georgia Tech was contracted to carry out the following activities:

- Assist local manufacturers in producing the AID hand pump
- Select field test sites and help prepare them for pump installation
- Assist Ministry of Health personnel and rural villagers in the installation, maintenance, and repair of the pumps
- Determine well water quality at pump sites by chemical and bacteriological analyses
- Test the locally manufactured pumps under field conditions to improve manufacturing quality control

Two integrated foundry and machine shop businesses, INDUSTROQUEL and Astilleros Navales Dominicanos, were chosen to manufacture the AID hand pump in the Dominican Republic. INDUSTROQUEL was a small shop in which the owners themselves function as machinists, production supervisors, salesmen, accountants, and overall managers of the business. Astilleros Navales Dominicanos was a very large and bureaucratic operation owned by the government, but operated on a competitive basis with the private sector. The latter appeared to have the best equipment and had a functional organizational structure with a sales manager, a chief engineer, and a supervisor for the machine shop and foundry operations.

Before contracting with the two manufacturers, an agreement was made to produce the shallow-well pump for $110 and the deep-well model for $135. However, after producing the first order, six shallow-well and six deep-well pumps by each, the manufacturers revised their quotes to $175 for the shallow-well and $198 for the deep-well pump. This price increase resulted in a loss of competitiveness with imported pumps, but even so, many advantages of local manufacture still existed. Recently, the Ministry of Health in the Dominican Republic received bids for 1,000 AID hand pumps, where the competition resulted in an accepted bid of $128 for both models from a local foundry and machine shop establishment, Equipo Tecnico Industrial.

In manufacturing the AID hand pump in the Dominican Republic, a prototype was available from Nicaragua that was very helpful to the pump manufacturers. However, the working drawings had to be translated into Spanish and the correct PVC pipe for lining the shallow-well pump was not available. In order to solve this problem, the PVC manufacturer had to run a special order of the correct size pipe. Project personnel now choose the nearest oversized outside diameter PVC pipe and turn it down to the correct size on a lathe so that standard diameter PVC pipe may be used. The first batch of finished pumps clearly showed manufacturing difficulties in adhering to specified tolerances. However, subsequent production has vastly improved.

Of the 24 test pumps manufactured, 21 were installed. All of these pumps are functioning well, especially those that have been kept lubricated. They have been in the field for close to 2 1/2 years with many not requiring even the first changing of leather cups.

As part of the project, work was peformed related to the quality of the water in the wells where the pumps were installed. An attempt was made to properly seal the wells to prevent the entrance of contamination and to disinfect the water. Some of the wells were placed too close to latrines (as close as 16 feet in one case). Even in these cases the wells were still used for testing because, prior to installation of the hand pumps, the villagers were using water from the wells and it was felt that the test results would provide useful information.

Concrete aprons were built extending five feet around the wells and a curb was placed around the aprons to keep sullage water away. A cover was placed over a manhole on the top of the well upper-structure used to provide access for the villagers to draw water in case the hand pump failed. A concrete pedestal was formed below where the hand pump rested after installation to prevent water from entering the well at the base of the pump where the pump's drop pipe passed through the upperstructure. However, the pedestal did not prevent water from entering the well at this point. A section of PVC pipe is now added when forming the pump supporting slab that serves both as a form for the well opening and prevents water from entering the well by extending approximately one inch above the slab.

In most cases, the wells were not adequately disinfected at the time of pump installation. A hand pump technician from the Ministry of Health was responsible for installing the pumps and disinfecting the wells. Though properly instructed in the correct dosage to "shock" chlorinate the wells, he felt that the increased dosage over what he was accustomed to administering was unnecessary. It is felt that the technician probably reverted to his own dosage when he was not being closely watched. This incorrect technique coupled with the fact that the Dominican Republic is underlaid with extensive fractured and fissured limestone and basalt, resulted in the analysis showing only one well with a low contamination level after pump installation.

Initial manufacturing problems were resolved through technical assistance and the Dominican Republic has officially accepted the AID hand pump for its own use. The Ministry of Health has entered an order for 1,000 hand pumps and later increased the order to 2,600. Thus, the overall impact of the AID/Georgia Tech program for the Dominican Republic is quite sizeable when all of the resulting benefits are weighed.

For 2,600 pumps at $128 each, AID and the Dominican Republic have already saved an estimated $450,000 by eliminating imports. The cost of stimulating local manufacture and providing quality control technical assistance was $45,000. Thus, the net savings of this program to date is over $400,000, and as other organizations and private consumers purchase the AID hand pump the net savings will increase. For the first time the Dominican Republic can boast complete local manufacturing of a heavy duty, low cost, low maintenance hand pump. The project also confirmed the soundness of the modifications recommended during testing in Nicaragua and Costa Rica.

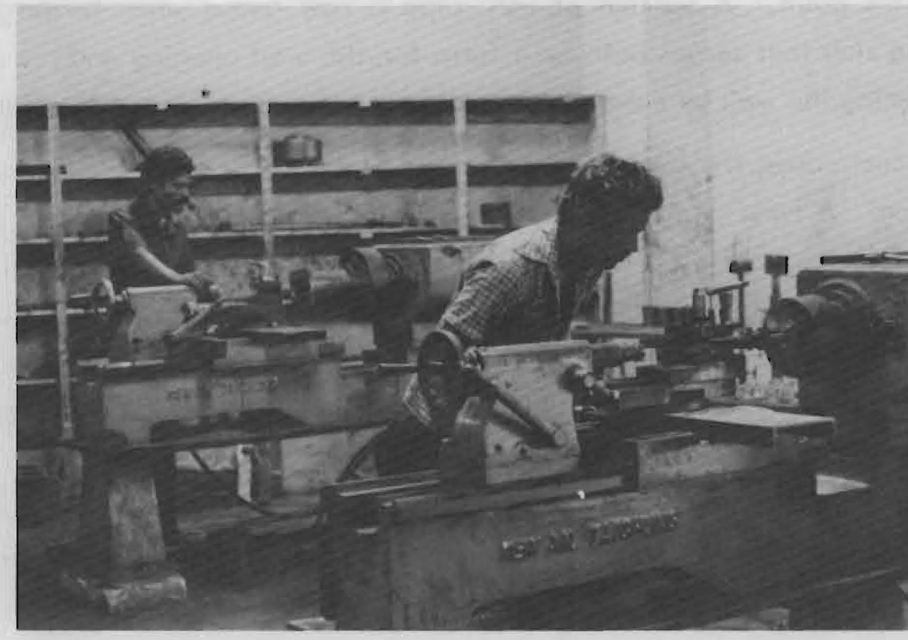


FIGURE 10. PRODUCTION OF THE AID HAND PUMP IN THE FOUNDRY/MACHINE SHOP, EQUIPO TECNICO INDUSTRIAL (DOMINICAN REPUBLIC)

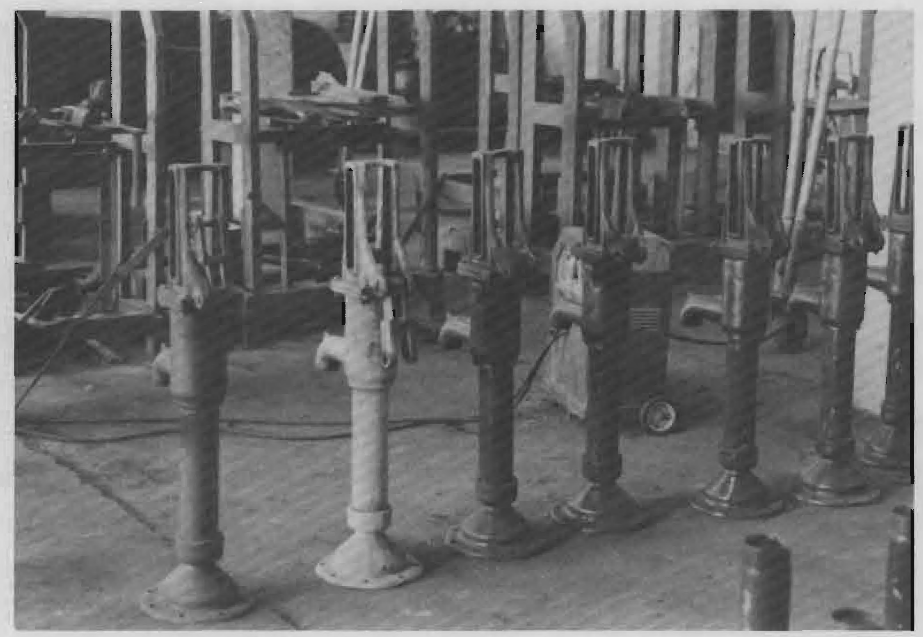


FIGURE 11. MASS PRODUCED AID HAND PUMPS (DOMINICAN REPUBLIC)

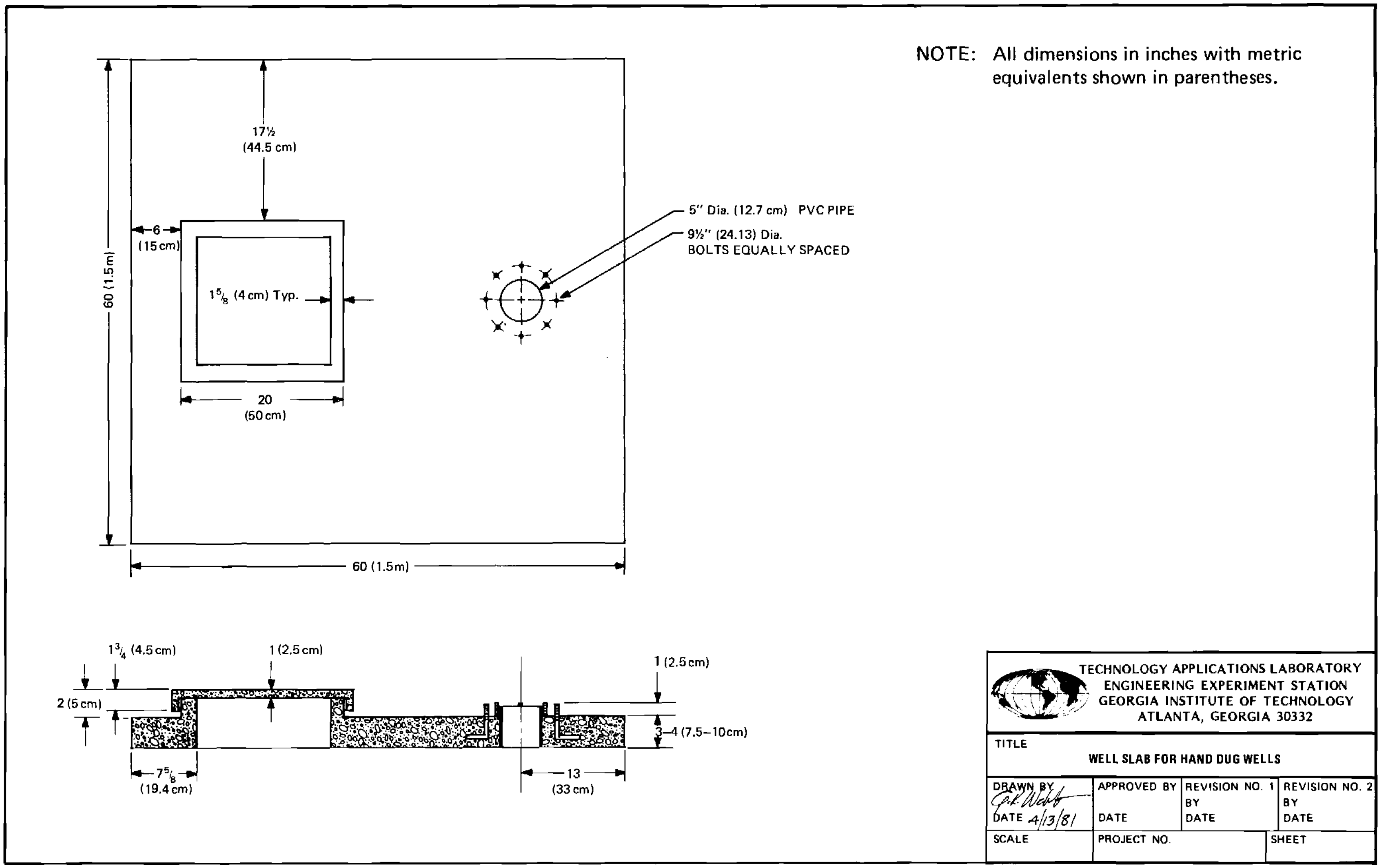


FIGURE 12. DIAGRAM OF WELL SLAB FOR HAND-OPERATED WATER PUMP

INDONESIA

The Indonesian AID hand pump program began in early 1978 when Georgia Tech personnel visited the country to:

- Explain the advantages of the AID hand pump to USAID/Indonesia and Indonesian government officials
- Estimate local costs for manufacturing the AID pump and compare with costs of purchasing locally available hand pumps (both locally manufactured and imported)
- Determine whether a market existed in Indonesia for hand pumps and if sufficient manufacturing capabilities were available for producing the AID pump

Data gathered from personal observations and very cooperative inputs by USAID/Indonesia, the Indonesian Ministries of Industry, Health, and Public Works, the World Health Organization (WHO), and CARE led to the conclusions that:

- The AID hand pump could be manufactured in Indonesia at an acceptable level of quality at several foundries and machine shops
- The AID hand pump could be manufactured at a reasonable cost
- The need for both urban and rural potable water supply programs involving cost-effective hand pumps was overwhelming

Based on the above findings, an AID/Georgia Tech contract was signed in September 1978 whereby Georgia Tech would provide technical assistance in producing 60 AID hand pumps. These 60 pumps were manufactured, tested, and accepted by Georgia Tech personnel for subsequent installation in the field in March 1979.

In August, 1979 the program was expanded to include:

- The coordination of manufacture, quality control, and formal acceptance of 170 additional deep- and shallow-well AID pumps
- Site selection and development and installation of 35 AID hand pumps in the Bandung area of Indonesia with a 12-month monitoring/evaluation and reporting period
- Site selection and development and installation of ten AID hand pumps in the Jakarta area of Indonesia for a WHO/Ministry of Health independent monitoring activity

- o Site selection and preparation, supervision, and installation of 20 AID hand pumps in six AID Provincial Development Program (PDP) project areas (Bengkulu, Kupang, Semarang, Banjarmasin, Surabaya and Banda Aceh)

- o Area assessment and evaluation of the feasibility of the local manufacture of the AID hand pump in at least three PDP areas

- o Provision of three AID hand pumps to each of 11 sites for village sanitarian schools as training aids

The AID hand pumps were manufactured by Celco Technical Industry, Ltd. in Bandung at a cost of $50 for the shallow-well pump and $60 for the deep-well model. The manufacturer's reluctance to accept quality control techniques suggested by project personnel was a major problem. As an example, simple jigs and fixtures were made for the manufacturer and not used until project personnel threatened to refuse payment for any pumps made without the use of these manufacturing aids. As a consequence, the manufacturer began using the jigs and fixtures and found that not only was production increased, but quality was consistent and pump components became interchangeable. Prior to use of the recommended manufacturing techniques, components were somewhat custom-made for each pump and if a replacement part was needed, it probably would not fit the pump for which it was intended.

A second quality control problem was due to the manufacturer's reluctance to establish adequate inspection procedures during the various production stages, a matter that has improved during the project but still is less than desirable. As an example, field data showed that the manufacturer neglected to consistently use high quality and properly sized leather for the pump's foot valve. Thus, failure of this very simple and inexpensive component resulted during use in the field. With better inspection procedures, the manufacturer would have prevented these failures.

Initially, leather cups wore out at an unacceptable rate, but this stopped after sand in the newly drilled wells settled down. Project personnel were also able to train installation teams to locate the pump cylinder so the presence of the sand would be minimized.

AID hand pumps are presently being installed in six PDP areas, the feasibility of manufacturing the pump in three PDP areas is being assessed, and at least one of three pumps designated for each of 11 sanitarian schools is being installed. In general, AID pumps installed in the field have responded well with the exception of the leather foot valve wearing out too frequently. This problem is being addressed through a better selection of leather and through alternative designs. Prospects for wide use of the AID pump now appear promising, as CARE has installed over 200 of these pumps and ordered 200 more for its own rural water supply programs. ADB is considering its use for 3,000 wells in the Sulawesi region. Other organizations are expected to use the pump as additional foundries are identified and exposed to the marketability of the pump. It is noteworthy that at one test site, villagers have taken up a collection and purchased three more pumps, developed well sites, and installed the pumps themselves.

CARE is providing villagers in the Bandung area with a set of tools and spare parts and training them in repair and maintenance. To date, the villagers are maintaining the pumps with minimal supervision by CARE personnel. As time goes by, the villagers should increase their maintenance and repair competency and are expected to be self-sufficient by the time the project terminates. This is a remarkable feat and CARE is to be congratulated for its endeavors.

FIGURE 13. MR. TANO T. JAKRASASMITA, THE OWNER/MANAGER OF CELCO TECHNICAL INDUSTRY, DISPLAYS HIS WOODEN PATTERNS OF THE AID HAND PUMP (INDONESIA)

FIGURE 14. A TYPICAL INSTALLATION PHASE OF THE AID HAND PUMP PROGRAM (INDONESIA)

SRI LANKA

In October 1979, Georgia Tech engineers were chosen to determine the feasibility of locally manufacturing the AID hand pump as well as other equipment applicable to water supply programs in Sri Lanka. Along with the AID hand pump, the investigation centered around the use of Robo devices developed by University of Maryland rural water supply specialists. This equipment includes the Robovalve, the Roboscreen, and the Robometer. The Robovalve is a plastic faucet that shuts off automatically to prevent water waste and associated health problems due to improper drainage. The Roboscreen is a plastic well screen/filter for removing suspended contaminants. The Robometer is a user-activated, pay-as-you-go water meter that reduces administrative costs by eliminating meter readers. The Robo devices were included in the Sri Lanka program to demonstrate their potential for local manufacture and applicability to rural water supply programs in developing countries.

In order to determine the manufacturing capabilities in Sri Lanka, project personnel visited wholesale and retail establishments, foundries, machine shops, and plastics manufacturers. Sri Lanka was found to be an ideal country for introduction of the AID hand pump since local manufacturers offered an attractive price and had the capability to manufacture a quality pump. Furthermore, the Government of Sri Lanka was committed to the goals of the United Nations Water Decade, and international development agencies concerned with Far East countries were gearing up for large programs in water and sanitation.

Well screens in Sri Lanka were seldom used, even with large capacity well installations, and thus the market was small for such technology as the Roboscreen. Manufacturing capabilities did exist, but manufacturer's quoted prices appeared to be unreasonably high.

Water faucets were available at hardware stores, but the bulk of these faucets were expensive and of poor quality. The Robovalve was an excellent alternative for replacing existing faucets because of its superior design, but quoted prices for its local manufacture also appeared to be unreasonably high.

Price quotes were not obtained for the Robometer because a prototype was not available, but there were sufficient plastics manufcturers, foundries, and machine shops to produce such an item in Sri Lanka. It was felt that the Robometer would be applicable in existing and upcoming piped water programs, most of which included the user paying for the water. Historically, in cases where there was a charge for water and meters were used to measure consumption, there was a problem of revenue collection that the Robometer could reduce or eliminate. Meters presently used were imported and cost anywhere from $150 to $300 while the Robometer production cost was estimated to be between $12 and $20.

Based on the above findings, USAID/Sri Lanka contracted with Georgia Tech in March 1980 for an AID hand pump program comprised of two tasks. The first task, still underway, calls for the following:

- Subcontract a selected Sri Lankan foundry to manufacture at least 88 AID hand pumps
- Provide working drawings and prototypes of the AID pump and sufficient technical assistance to insure high quality finished products
- Provide technical assistance in quality control
- Formally accept and certify all AID hand pumps manufactured

A contract was signed in March 1980 with a foundry and machine shop, Somasiri Huller Manufactory, for the production of 90 AID hand pumps. The contract calls for 45 shallow-well pumps at a unit cost of $78 and 45 deep-well pumps at a unit cost of $84. Working drawings, prototypes of the pump, and technical assistance have been supplied the manufacturer. Somasiri Huller is still working to complete the order because of a backlog of production, but the pumps produced thus far are of excellent quality. Other organizations such as a British consulting firm and UNICEF are waiting to enter orders for the AID hand pump for their own use.

While Somasiri Huller initially agreed to manufacture the AID pumps at $78 (shallow-well) and $84 (deep-well), experience with the finished pumps has shown that these prices were underestimated. The contract with the manufacturer has now been amended to reflect a price of $160 per pump (shallow-well or deep-well). Despite the fact that this $160 figure is twice the original estimate, it is still attractive as an alternative to the only other hand pump being used in Sri Lanka, the India Mark II, which costs slightly over $300 delivered.

As mentioned previously, the AID hand pumps produced thus far are of excellent quality and the second task of the project has begun. This task calls for:

- Installing the completed AID hand pumps in five major areas over newly prepared or reconditioned existing wells

- o Disinfecting well waters with a chlorine-yielding compound
- o Analyzing well waters for water quality
- o Providing spare parts and training in hand pump maintenance procedures to village caretakers.
- o Monitoring and evaluating pump performance to provide quality control information to the manufacturer

By December 1981, Somasiri Huller should be capable of producing the AID hand pump at a high level of quality without external technical assistance and able to supply national and international organizations on a large-scale basis. However, to meet the demand from these organizations, Somasiri Huller will have to increase production capacity or a second supplier will have to be developed.

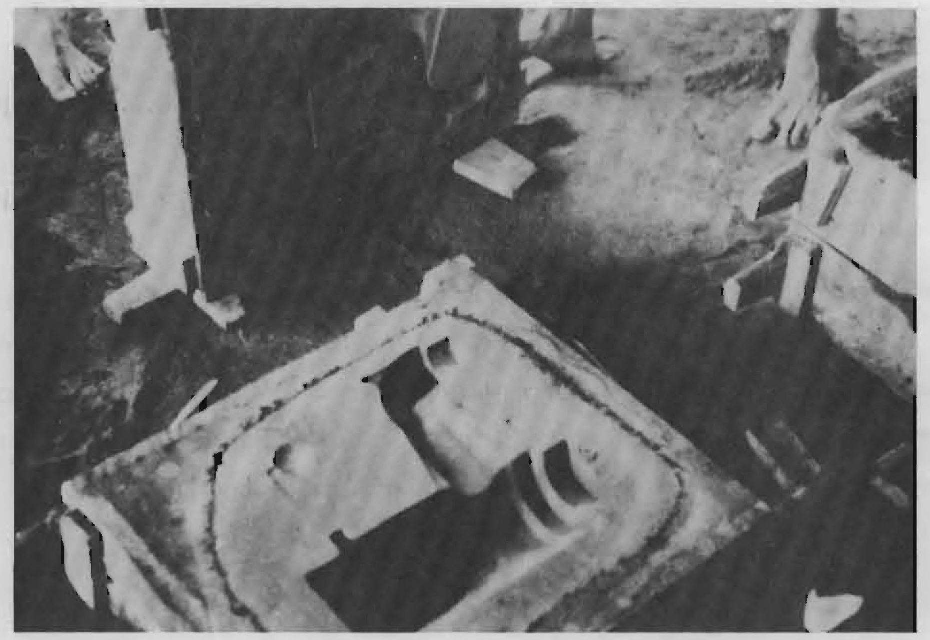


FIGURE 15. A PARTIAL MOLD PREPARED FROM THE PATTERN OF THE AID HAND PUMP SPOUT. MOLTON IRON WILL BE POURED INTO IT FOR CASTING OF THE PUMP COMPONENT (SRI LANKA)

FIGURE 16. AID HAND PUMP COMPONENTS AFTER CASTING (SRI LANKA)

FIGURE 17. SERUPITA, SRI LANKA VILLAGERS HELP DEVELOP AN EXISTING WELL FOR INSTALLATION OF TWO AID HAND PUMPS

FIGURE 18. SLAB FOR AID HAND PUMPS (SRI LANKA)

FIGURE 19. FINAL TOUCHES ADDED TO THE SLAB AT SERUPITA (SRI LANKA)

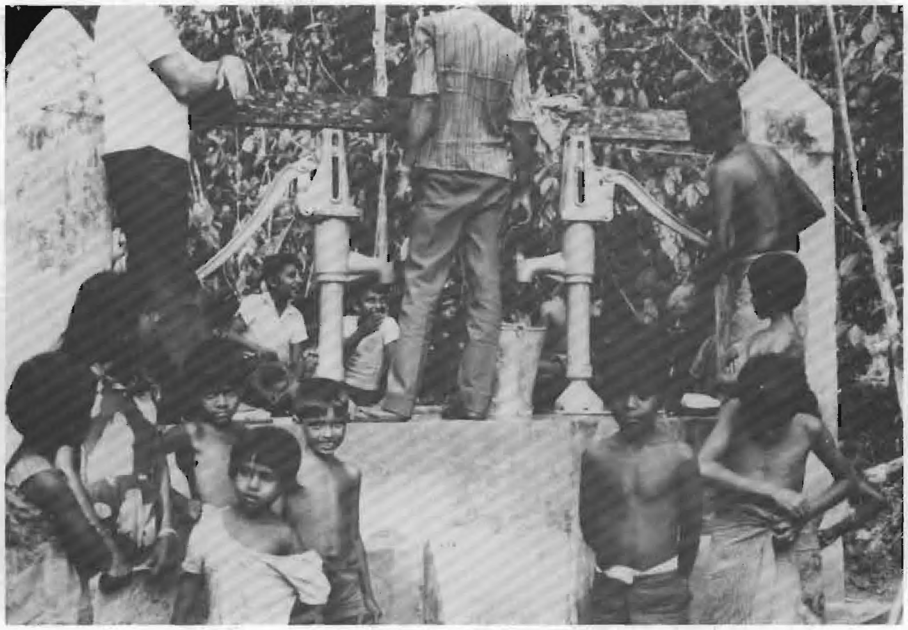


FIGURE 20. AID HAND PUMPS INSTALLED AND READY FOR HEAVY USAGE (SRI LANKA)

TUNISIA

In April 1980, a Georgia Tech team visited Tunisia to determine the feasibility of locally manufacturing AID hand pumps and Robo devices. Field trips at that time indicated a serious lack of adequate water supplies in rural areas. Where sources of water were available, rural citizens traveled long distances to water their livestock and gather water of questionable quality for domestic use. In many cases, the volume was insufficient to meet the demand.

Surveys of Tunisian foundries, machine shops, plastics manufacturers, and retail hardware stores indicated that local manufacture of the AID hand pump and the Robo devices was both technically and economically feasible as a viable alternative to expensive imports. One foundry, Les Founderies Reunies, was chosen to manufacture a quality AID hand pump at an attractive unit price of $232. The imports being considered by the Government of Tunisia, USAID/Tunisia, and CARE were the U.S. manufactured Moyno at $500 and the French manufactured Vergnet at $800. Two plastics manufacturers, Societe des Applications Plastique and Inoplast, were determined to be capable of producing Robo devices. In particular, Societe des Applications Plastique seemed well-suited to manufacture the Robovalve and Inoplast had the expertise and equipment to fabricate the Roboscreen.

In August 1980, a contract was signed between USAID/Tunisia and Georgia Tech to provide technical assistance to the Government of Tunisia and USAID/Tunisia in manufacturing AID hand pumps, Roboscreen, and Robovalves. The contract also called for testing the products under conditions existing in Tunisia. More specifically, Georgia Tech was to carry out the following program of work:

- Provide technical assistance to USAID/Tunisia, the Government of Tunisia, and private volunteer organizations (PVO's) implementing rural water supply programs

- Oversee production of 40 AID hand pumps, 200 Robovalves, and 500 feet of Roboscreen

- Provide working drawings, prototypes, and technical assistance in proper production techniques and quality control

- Inspect, test, and accept the AID hand pumps, Robovalves, and Roboscreen

- Develop at least ten sanitary wells and upper structures, install AID hand pumps and Roboscreen, disinfect well waters, and determine chlorine residuals

- o Monitor and evaluate performance of the AID pumps, Robovalves, and Roboscreen
- o Provide feedback to manufacturers for quality control

In September 1980, an order was placed with Les Founderies Reunies for 40 AID hand pumps at a unit cost of $232. This price will be adjusted before final payment is made because of modifications requested by USAID/Tunisia and CARE. The traditional AID deep-well hand pump has previously been manufactured with a three inch inside diameter cylinder that is connected to the pump by a 1 1/4 inch drop pipe during installation. In Tunisia, this approach was not thought to be practical because of the difficulty in removing the piston assembly for periodic changing of leather cups that normally requires two to three hours. Consequently, the AID pump manufactured in Tunisia will have a 2.1 inch diameter PVC drop pipe that also serves as a cylinder. This allows leather cups to be changed by removing the pump cap and pulling the piston assembly up through the drop pipe and pump, changing the leather cups, and replacing the piston assembly back through the pump body and into the drop pipe. This approach should enable maintenance crews to change leather cups in less than 30 minutes.

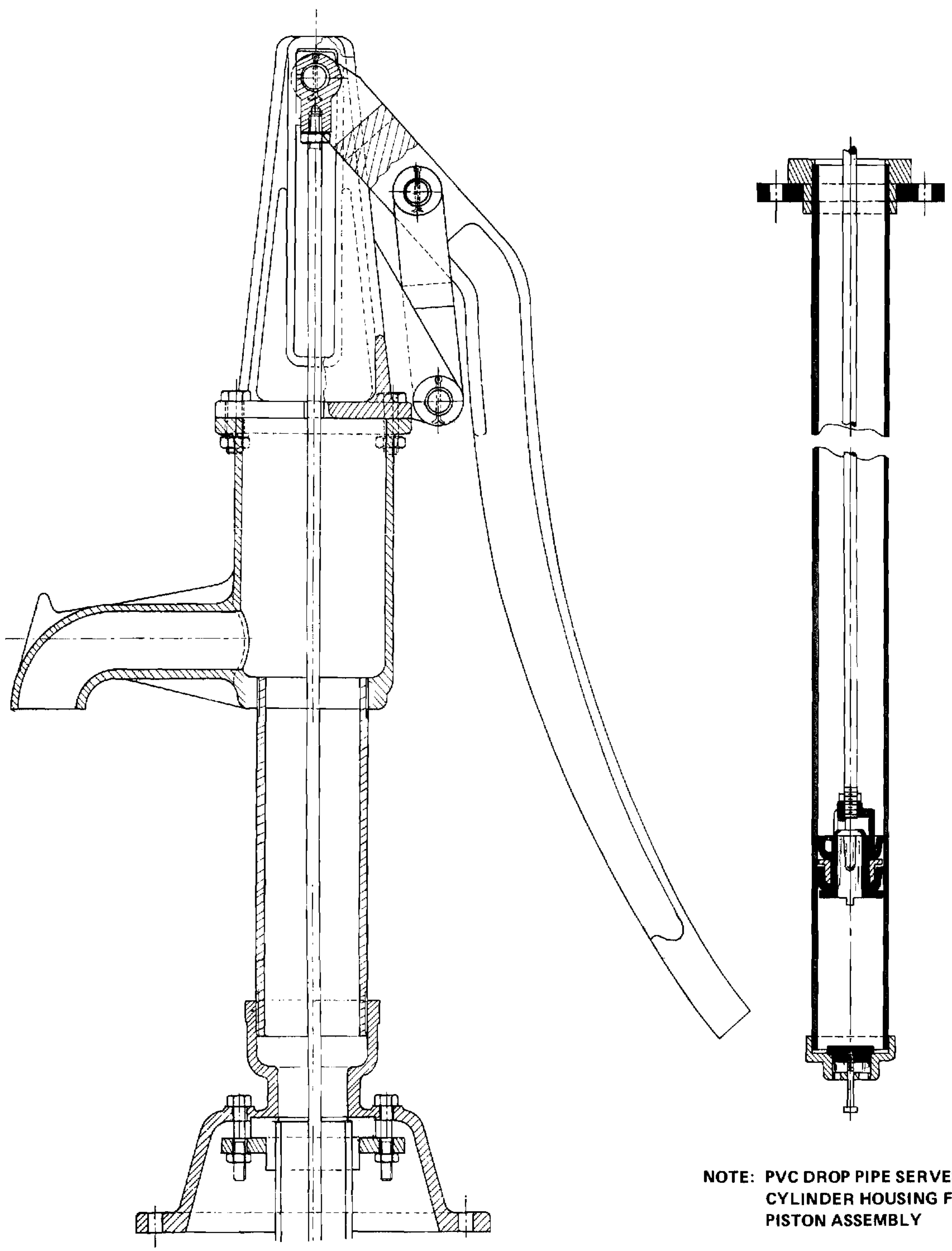
In January 1980, Les Founderies Reunies presented a production prototype of the AID hand pump to AID/Tunisia and Georgia Tech personnel for approval before going into regular production. The prototype was mounted over a drum of water and thoroughly tested. After a complete inspection, it was concluded that the pump was of very good quality and should perform well in the field. Approval was then given to proceed with the production of the 40 ordered pumps, which will be ready for installation in April 1981.

A public standpost model of the Robovalve has been field tested in Tunisia from models supplied by AID/Washington. While field test data has shown some design problems, it is felt that, with certain modifications, an order for 200 valves can be placed in the near future with Societe des Applications Plastique. Societe des Applications Plastique has a quality-conscious operation that includes in its product line items from cigarette lighters to plastic tables and chairs. Plastic containers are also produced that are adaptable to household water containers with purification units. Production equipment and machinery are new, in good condition, and well laid out in the plant for efficient operations. Therefore, it is expected that this company will produce a quality Robovalve once an order is placed even though quality control technical assistance will be required.

During April and May 1981, the AID hand pumps will be installed in the field after capping preselected existing wells. Installation will be a joint effort of Georgia Tech, CARE, and Ministry of Agriculture personnel. If the pump performs as expected, the Government of Tunisia and CARE will use it in future hand pump programs. At the same time the AID hand pumps are being installed, production orders will be placed for manufacturing the Robovalves. Because of a reluctance by Tunisian Ministry of Agriculture engineers to accept the concept of plastic well screen, the Roboscreen will probably not be introduced until a later date.

Figure. 21

AID HAND–OPERATED WATER PUMP, DROP PIPE AND PISTON ASSEMBLY MANUFACTURED IN TUNISIA

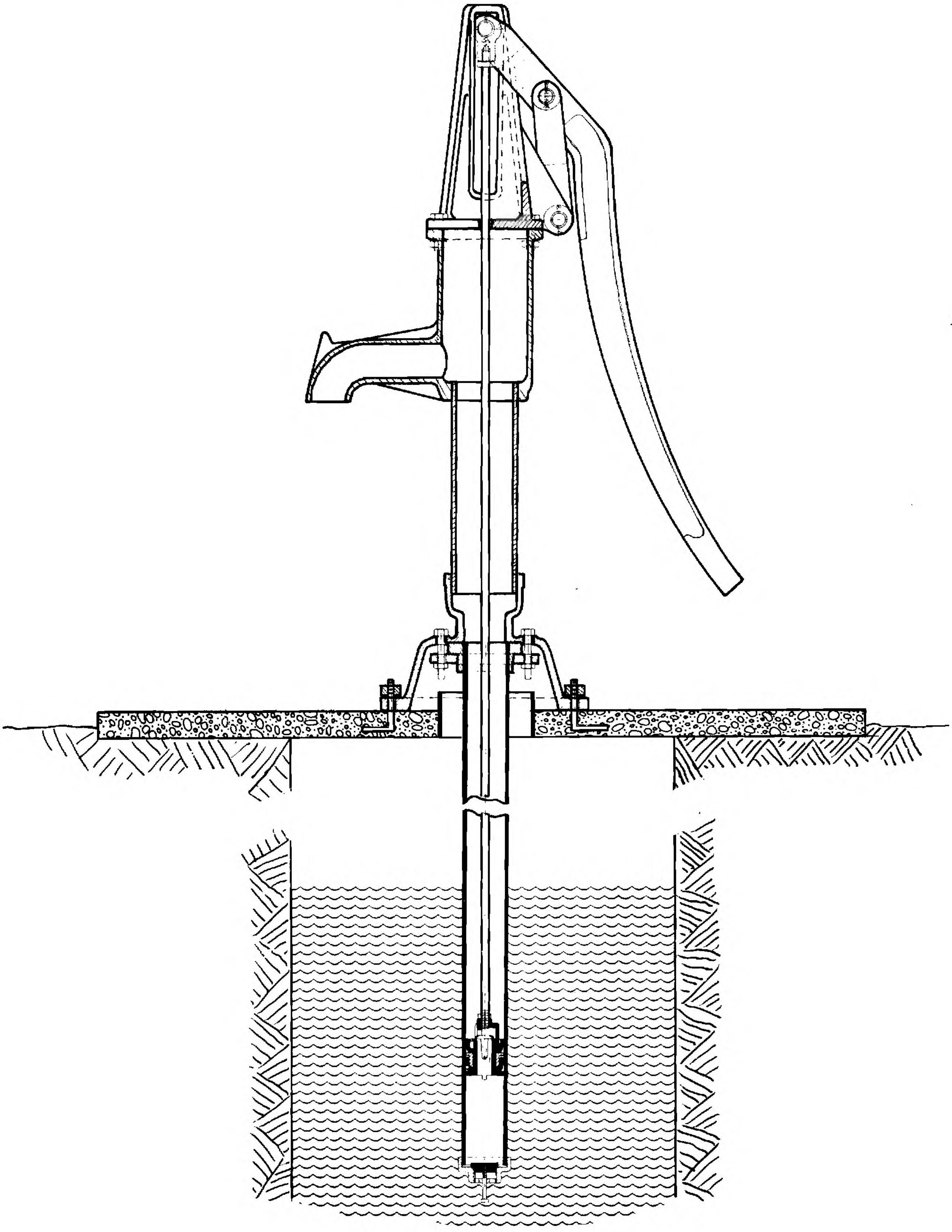


NOTE: PVC DROP PIPE SERVES AS CYLINDER HOUSING FOR PISTON ASSEMBLY

Figure. 22

TYPICAL AID HAND–OPERATED WATER PUMP

INSTALLATION IN TUNISIA



ECUADOR

In August 1980, a Georgia Tech team visited Ecuador to determine the feasibility of locally manufacturing the AID hand pump, Roboscreen, Robovalve, and Robometer. The study revealed that much could be done to improve living conditions for Ecuadorian citizens, especially those in the rural areas, by providing safer and more convenient water.

The leading causes of death in Ecuador were found to be related to underdevelopment and poor environmental conditions, and were often preventable. Even though the country's health status was related to many socioeconomic factors, environmental sanitation and water supply had the most widespread impact. In 1978, household connections to public water systems supplied most of the urban population, but for over half of the population living in the rural areas, coverage was a dramatically low 16%. Therefore, the effect of lack of access to potable water on health and overall economic development was found to be substantial. The Government of Ecuador and development agencies such as USAID/Ecuador, CARE, and the Community Development Department of Voz Andes Hospital were working toward improving these conditions. Because of this interest and a great need for an improved water supply in Ecuador, it seemed natural to stress local manufacture of as much of the needed hardware as possible.

In September 1980, a contract was signed between AID and Georgia Tech to provide technical assistance to the Government of Ecuador and USAID/Ecuador in locally manufacturing AID hand pumps, Robovalves, and Roboscreen and assuring their applicability for introduction into bilateral health projects. The contract, still current, is to:

- Oversee production of at least 100 AID hand pumps, 2000 Robovalves, and 1,000 feet of Roboscreen
- Provide working drawings, prototypes, and technical assistance in proper production techniques and quality control
- Inspect, test, and accept the finished AID hand pumps and Robo devices before installation in the field
- Train recipient organizations in the proper sanitary preparation of wells, equipment installation techniques, disinfection of water, bacteriological water analysis, and maintenance and repair of AID hand pumps

A contract has been signed with the Escuela Politecnica Nacional for the manufacture of the AID pumps at $150 per pump. The first order should be ready for installation in the field by May 1981. A contract has also been signed with an Ecuadorian plastics manufacturer, Industrias I.E.P.E.S.A., for injection molding Robovalves, Roboscreen, and pump cylinders. The unit cost of the Robovalves will be $1.75, the Roboscreen will cost $1.36 per linear foot for two inch inside diameter and $2.82 per linear foot for four inch inside diameter, and the pump cylinders will be $2.21 each excluding end caps and foot valve.

The AID hand pump will be manufactured to the same specifications as previously described except that the pump cylinder will be injection molded ABS plastic rather than PVC extruded pipe. This design change is required because PVC pipe could not be purchased in the desired diameter and wall thickness. This change is actually quite attractive since ABS has a lower coefficient of friction and is harder than PVC which should result in longer life for the leather cups and lessened susceptibility to abrasive materials such as sand for the pump cylinder.

In June 1981, the AID hand pumps and the Robo devices will be installed in rural areas of Ecuador by the following organizations:

- CARE
- Peace Corps
- Voz Andes Hospital
- Ecuadorian Institute of Sanitary Works (a department of the Ministry of Health)
- Center for the Rehabilitation of Manabi (a provincial government development authority)

Training in site selection, well preparation, equipment installation techniques, proper disinfection of water, bacteriological water analysis, and maintenance and repair will be provided by Georgia Tech personnel.

These activities should result in national acceptance of the AID hand pump and the Robo devices into future Ecuadorian rural water supply programs. In June 1981, the first lady of Ecuador, Mrs. Martha de Roldos, will participate in a ceremony announcing the production of the first AID hand pump in Ecuador as a continuing commitment to rural development by the President.

OTHER COUNTRIES

Honduras, the Philippines, Bolivia, Togo, Benin, and Liberia have been surveyed by Georgia Tech to determine if the AID hand pump is appropriate and can be manufactured at a competitive cost. Manufacturing, field testing, and pump performance monitoring and evaluation activities are expected to begin in Honduras and the Philippines soon due to positive results from the surveys and interest on the part of the respective AID missions and host country organizations in promoting the AID hand pump's local manufacture. AID hand pump programs have not materialized in Bolivia, Togo, Benin, and Liberia.

In Bolivia, the need for hand pumps was great with an immediate market demand of over 9,000 units in April 1979 and sufficient manufacturing capabilities existing to produce the AID hand pump at a cost of approximately $70 each. However, the majority of the hand pumps being installed in Bolivia in 1979 were part of the Ingavi Integrated Rural Development Project and utilized the Ingavi hand pump, which was locally manufactured, inexpensive ($57), and easily maintained. The AID hand pump had certain advantages over the Ingavi hand pump as it was more suitable for deeper wells, sturdier, and probably more cost-effective over long periods of time. However, the Government of Bolivia was committed to using the Ingavi hand pump because it had been developed by the World Bank for its programs, which represented most of the rural water supply programs at that time. Under these circumstances it would have been needless and difficult to introduce another hand pump.

Togo and Benin were analyzed in June 1979 to determine the feasibility of locally manufacturing the AID hand pump. The majority of the rural villagers could be served by providing 8,000 pumps in Togo and 11,000 pumps in Benin. The necessary machine shops and foundry skills were available for manufacturing the pump. However, the AID pump was not considered appropriate for these countries by AID and national government officials because the wells in Togo and Benin were extremely deep. The majority were between 100 to 300 feet and the AID pump could only be used to a maximum of 150 feet (with a 2-3 inch cylinder). Using a hand-operated water pump at depths greater than 150 feet might be desirable but was beyond the limits of most reciprocating type hand pumps. As a result, two U.S. Moyno rotary hand pumps were installed in each country for demonstration and trial purposes. Even this type of pump was beyond practical human energy limits of the strong, well-built men in Togo and Benin. The Liberty hand pump used in the Philippines would be most applicable in Togo and Benin since it has a wooden handle 20 to 30 feet in length for the extra leverage needed in such deep wells. The Liberty could pump routinely from 300 to 600 feet using a train of seven leather cup piston assemblies with a one-inch diameter drop rod.

Liberia was also investigated for possible local manufacturing of the AID hand pump. However, there were no foundries and machine shops with adequate manufacturing equipment and skills for producing such a product.

FIGURE 23. AN INGAVI HAND PUMP INSTALLED IN THE COMMUNITY OF ACHICA ARRIBA IN THE PROVINCE OF INGAVI, BOLIVIA

TECHNOLOGY TRANSFER METHODOLOGY

Georgia Tech has been heavily involved in international technology transfer programs for the past 17 years. These programs have included assistance to governments and development institutions worldwide in planning and implementing industrial and economic development projects. Georgia Tech has also participated in small industry development and assistance programs, economic development training, technical information service to industry, and feasibility and market studies. A continuing involvement with technology transfer is a major part of Georgia Tech's commitment to improving the quality of life in less developed countries. Technology transfer implies not only the adaptation of technology to existing environmental conditions, but also the maximum utilization of local resources, the stimulation of initiative and innovation, and the development of logistical support within a basic cost-effective framework. The AID hand pump programs at Georgia Tech have met these criteria and a methodology has been devised for working with private sector manufacturers and cooperating government organizations to stimulate the local fabrication, installation, and monitoring of water and sanitation technology.

This methodology is not complicated and can be easily applied in a variety of countries and with a variety of different devices. The AID hand pump programs have begun with a determination of applicability of the technology to be transferred. This phase has included investigating such factors as the need for water supply programs, population densities, and the existence of private or government infrastructures that have the capabilities and the resources for developing water supply programs. The demand for hand pumps is compared to existing or potential supply sources. Local manufacturing capabilities are analyzed for the level of expected quality at a price competitive with other available hand pumps.

If the first phase is positive, the second phase is implemented that involves a relatively small production run to test the true capabilities of the manufacturer. During this phase, the manufacturer is supplied with working drawings, prototypes, and technical assistance in production techniques and quality control procedures. Manufacturing cost data is recorded to assure the manufacturer that it is possible to produce the hand pump and realize a profit. During the different stages of production, quality control checks are required. Completed pumps are tested in-plant for overall performance and if found to be satisfactory, they are installed in the field for performance monitoring and final evaluation. As manufacturing defects are discovered during field testing, information is fed back to the manufacturer and methods are formulated for correcting the manufacturing problems.

Field testing is a necessity for "debugging" the newly manufactured AID hand pumps, as well as having other valuable benefits. Since wells must be developed, well waters properly disinfected and analzyed chemically and bacteriologically, pumps installed over the well, and maintenance and repair provided, the hand pump recipients are given on-the-job training in each of these activities.

The use of host country counterparts should be mentioned, as they have played a major role in each country. The counterpart organizations are in-country international, national, or regional governmental agencies, development institutions, and/or PVO's that allow Georgia Tech more efficient utilization of funds. These counterparts carry out the day-to-day operations of the project while Georgia Tech personnel provide the technical and project management resources necessary to the success of the project. At the same time, they provide established working relationships with existing communities, industries, lending institutions, and government departments that save considerable time and effort when establishing operations in a new country.

Host country counterparts that have participated in the hand pump programs are CARE (Indonesia, Tunisia, and Ecuador), the Peace Corps (Nicaragua and Ecuador), Ministries of Health (Nicaragua, Costa Rica, Dominican Republic, Ecuador, and Indonesia), Ministry of Agriculture (Tunisia), the Central American Research Institute for Industry (Nicaragua, Costa Rica, and Ecuador), Voz Andes Hospital's Community Development Department (Ecuador), and AID Missions in all countries where the programs have been carried out. Without these organizations, the success of the AID hand pump programs would have been more difficult and extraordinarily high in cost.

Through its methodology, Georgia Tech has concluded that the AID hand pump can be manufactured in many developing countries at a competitive price when compared to imported hand pumps. The AID pumps have exhibited excellent operational and maintenance characteristics and the designs have proven to be readily usable and culturally acceptable in all field situations.

Much detailed work is involved in initiating the local manufacture of any product such as the AID hand pump in developing countries. Manufacturers must be assisted in reaching a satisfactory level of quality control, and developing country implementing organizations must be made fully aware of the hand pump's capabilities and problems. Programs of this type require patient, prolonged, and understanding work with the personnel of a variety of private, government, and international organizations to share the knowledge and techniques of industrial nations with developing countries through adaptation rather than duplication and procurement.

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Project A-1894

FIRST PROGRESS REPORT ON THE UTILIZATION/EVALUATION OF AN AID HAND-OPERATED WATER PUMP

Prepared for the

U. S. Agency for International Development

by

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Summary

In September 1976, the Engineering Experiment Station, Georgia Institute of Technology (Georgia Tech) entered into an agreement with the Agency for International Development (AID) to evaluate (1) the performance and acceptability of a hand-operated water pump, previously designed for AID, in comparison with other pumps used in developing countries, and (2) the feasibility of local manufacture of the AID pump. This program has involved Georgia Tech in planning, installing, monitoring, and reporting upon a field test of the AID pump in Costa Rica and Nicaragua, using a counterpart organization, the Central American Research Institute for Industry (ICAITI, El Instituto Centroamericano de Investigacion y Tecnologia Industrial).

Costa Rica and Nicaragua were chosen as test countries because of sizeable loans that had been made to them by AID and because of their need for an expanded water-pump program. Provisions of the loan specifically included installation of water pumps on a large-scale basis, and it was felt that using Costa Rica and Nicaragua as test countries would enable them to get a better start on their own programs. Ministry of Health and AID officials also strongly felt that local manufacturing offered by the Georgia Tech/ICAITI program had many advantages that should be included in each country's respective loan program (mainly employment generation and spare parts availability).

Active work began in Costa Rica in January 1977, when AID/Washington and Georgia Tech jointly agreed that Costa Rica and Nicaragua should be the test countries for the program described herein. A machine shop, subcontracting to a local foundry for iron castings, was contracted with for the manufacture of 20 AID pumps (eleven deep-well and nine shallow-well) which were produced and delivered to a Ministry of Health warehouse for storage, prior to installation, in April. Two different kinds of pumps were chosen to compare the AID pump with: a Dempster model 210F and a Japanese Kawamoto Daiichi "Lucky" pump. Thirty sites, representative of Costa Rica, were chosen to receive the test pumps (15 AID pumps and 15 competitive pumps), all of which already had installed pumps varying in condition from broken to fully operational. Wells were randomly tested by chemical and bacteriological analyses prior to test-pump installation and found to contain large amounts of intestinal bacteria, indicating that contamination was not being sealed off from the water. Pumps

are now being installed, the wells are being disinfected with a chlorine-yielding compound, and the contamination sources are being sealed off (bacteriological testing will continue throughout the project to determine if the contamination is, in actuality, being sealed off). The monitoring of pump performance for a 12-month period is now under way and will continue through July 1978.

Program activities also began in Nicaragua in January of this year. A local foundry was chosen to manufacture 20 AID pumps (eleven deep-well and nine shallow-well) which were produced and delivered to a Ministry of Health warehouse for storage, prior to installation, in May. Three kinds of pumps were chosen to compare the AID pump with: Dempster, a Brazilian Marumby pump, and a pump developed by the International Development Research Centre (IDRC) of Ottawa, Canada. Thirty sites, representative of Nicaragua, were approved to receive the test pumps (15 AID pumps and 15 comparative pumps), all of which required extensive preparatory work before pumps could be installed. Pumps are now being installed, and the wells are being disinfected with a chlorine-yielding substance. As in Costa Rica, the sites have been randomly sampled for chemical and bacteriological analysis prior to installation of test pumps and show intestinal bacteria, requiring further testing to determine if the contamination is being sealed out by the addition of a closed well and the use of a hand pump for lifting the water. The 12-month monitoring period has begun and will continue through July 1978.

There are no indications at the present time that would discourage further manufacture, installation, or use of the AID pump in Costa Rica or Nicaragua. The AID pump can be manufactured in a developing country at a competitive, profitable price and at an acceptable level of quality if adequate facilities are available; however, the availability of adequate foundry facilities is a matter that must be determined for each individual developing country. Public acceptance by rural villagers has been good, both from an aesthetic standpoint and from a standpoint of the pump being used easily by men, women, and children. The AID pump is also very marketable if distribution channels and financial resources within the developing countries allow its purchase and installation, either by federal governments or by private citizens affluent enough to purchase and install the pump. Lastly, the AID pump should have a positive impact in developing countries on the health of rural people, on employment generation, and on instilling national pride within the people when it is seen that these countries do have local capabilities for manufacturing a complicated product rather than importing it.

INTRODUCTION

In September 1976, the Engineering Experiment Station, Georgia Institute of Technology (Georgia Tech) entered into an agreement with the Agency for International Development (AID) to evaluate (1) the performance and acceptability of a hand-operated water pump, previously designed for AID, in comparison with other pumps used in developing countries, and (2) the feasibility of local manufacture of the AID pump. This program has involved Georgia Tech in planning, installing, monitoring, and reporting upon a field test of the AID pump in Costa Rica and Nicaragua, using a counterpart organization, the Central American Research Institute for Industry (ICAITI, El Instituto Centroamericano de Investigacion y Tecnologia Industrial).

Organizationally, Georgia Tech has had overall responsibility for the AID water-pump field testing. Members of the Engineering Experiment Station have been, and are currently, involved in national and international programs of community and area development, management and technical assistance to business and industrial firms, industrial and economic development training, market analyses, studies of new manufacturing opportunities, manpower resources and labor productivity, stimulation of small-scale industry, technology assessment, development and conservation of energy resources, housing resources, industrial economics, economic uses of industrial wastes, adaptive technology research and development, audiovisual presentations and multimedia documentation, and professional guidance in planning industrial and economic development programs.

ICAITI, chosen as a Central American counterpart to enable efficient utilization of travel funds, to provide quick response to AID and to the Ministries of Health in Costa Rica and Nicaragua, and to take full advantage of its established working relationships with existing communities, industries, lending institutions, and governmental departments of Costa Rica and Nicaragua, is very similar to the Engineering Experiment Station. For more than 14 years, ICAITI has made significant contributions to the industrial development of Central America and has also completed a considerable number of related projects that have aided in the accomplishment of this program.

The program, more specifically, consists of participation by Georgia Tech and ICAITI in the following activities:

1. Providing technical assistance for selected foundries and machine shops to locally manufacture the AID pump.

2. Purchasing the AID pump and comparative pumps available on the local, open market.

3. Selecting 60 field-test sites for installation of 30 AID pumps and 30 locally-available pumps (30 sites to be located in each of the two test countries).

4. Determining the quality of water through chemical and bacteriological analysis.

5. Preparing sites (preparing new wells or rehabilitation of existing wells, as necessary).

6. Installing pumps.

7. Monitoring pump performance for a 12-month period.

8. Collecting and analyzing field data.

In gathering and analyzing data on the AID pump, seven areas have been of major concern:

1. Operational performance in the field.

2. Maintenance requirements and pump reliability.

3. Competitive cost and analysis of the economics of in-country manufacturing.

4. Manufacturing problems encountered.

5. Needed design changes and future utilization.

6. Public acceptance and marketability.

7. AID pump design characteristics and specifications.

COSTA RICA

It is universally accepted that an adequate supply of water for drinking, personal hygiene, and other domestic purposes, and an adequate means of waste disposal are essential to public health and well-being. Unfortunately, vast numbers of people in the developing world, most of them living in rural areas, do not have access to a safe and convenient source of water. When safe and convenient sources are available, satisfactory sewage disposal facilities normally are still unavailable.[1/]

Costa Rica was chosen as a test country because of a sizeable loan that had been made to that country by AID and because of the country's need for an expanded water-pump program. Provisions of the loan specifically included installation of water pumps on a large-scale basis, and it was felt that using Costa Rica as a test country would enable that country to get a better start on its own program. Costa Rican Ministry of Health and AID officials also strongly felt that local manufacturing offered by the Georgia Tech/ICAITI program had many advantages that should be included in the Costa Rican loan program (mainly employment generation and spare parts availability).

One aspect of this project that has been obvious from the beginning is that, even though Costa Rica is a developing country, it is much more developed than Nicaragua, and this shows up in the availability of potable water supplies for the two countries. For instance, based on early surveys, representative test sites chosen for this project show an average usage by approximately 75 persons in Costa Rica and 150 persons in Nicaragua. In Costa Rica, most communities of 250 inhabitants or more have some form of piped water system, while in Nicaragua, the size of the community will usually exceed 2,000 inhabitants before piped water is found. In Costa Rica, most communities will have at least one well with a pump, if not piped water, and in Nicaragua, springs, rivers, and open, dug wells are the common sources of water. Costa Rica has a greater degree of electrification in rural areas, allowing the installation of motorized pumping systems that are not possible in many areas of Nicaragua. Further, the Ministry of Health in Costa Rica has had a hand-pump water program for some fifteen years, while Nicaragua is just now in the beginning stages of such a program.

1/ Robert J. Saunders and Jeremy J. Warford, Village Water Supply, (Baltimore, Maryland: The Johns-Hopkins University Press, 1976), p. 3.

This does not mean that Costa Rica is without a need for improvement in its potable water delivery system. The Ministry of Health, for instance, estimates that, at the present time, as many as 47,000 hand-operated water pumps are needed to provide a suitable water supply to the country's rural citizens. Further, many existing water pumps are inoperable because of a lack of maintenance and, where there are functioning pumps, many of the well structures are poorly designed and ineffective in sealing out contamination.

Active work began in Costa Rica in January 1977, when AID/Washington and Georgia Tech jointly agreed that Costa Rica and Nicaragua should be the test countries for the program described herein. A machine shop, subcontracting to a local foundry for iron castings, was contracted with for the manufacture of 20 AID pumps (eleven deep-well and nine shallow-well) which were produced and delivered to a Ministry of Health warehouse for storage, prior to installation, in April. Two different kinds of pumps were chosen to compare the AID pump with: a Dempster model 210F and a Japanese Kawamoto Daiichi "Lucky" pump. Thirty sites, representative of Costa Rica, were chosen to receive the test pumps (15 AID pumps and 15 competitive pumps), all of which already had installed pumps varying in condition from broken to fully operational. Wells were randomly tested by chemical and bacteriological analyses prior to test-pump installation and found to contain large amounts of intestinal bacteria, indicating that contamination was not being sealed off from the water. Pumps are now being installed, the wells are being disinfected with a chlorine-yielding compound, and the contamination sources are now being sealed off (bacteriological testing will continue throughout the project to determine if the contamination is, in actuality, being sealed off). The monitoring of pump performance for a 12-month period is now under way and will continue through July 1978.

Manufacture of AID Pumps

A contract was signed with Mecanizados Mofama, S.A., located near San Jose, on January 28, 1977, for the manufacture of nine shallow-well type AID pumps and eleven deep-well type AID pumps. The prices of the pumps were as follows:

Shallow-Well	$ 98 (each)
Deep-Well	128 (each)
Patterns	498 (one-time charge only)

The pumps were manufactured according to the AID-approved drawings contained in the appendix to this report and with the following additional instructions:

1. The plunger rod was to be made from one-half inch diameter rod, rather than seven-sixteenths inch, because of difficulty in locating a reliable supply of seven-sixteenths inch stock. The pump rod nut, the rod end, and the plunger assembly were also changed to accommodate the one-half inch plunger rod.

2. The handle pivot pins were to be hardened to 40 R_C and steel bushings (60-64 R_C) inserted in the pump handle holes. By taking this approach, the pins are expected to wear out before the handles, allowing easier repairs at the least cost.

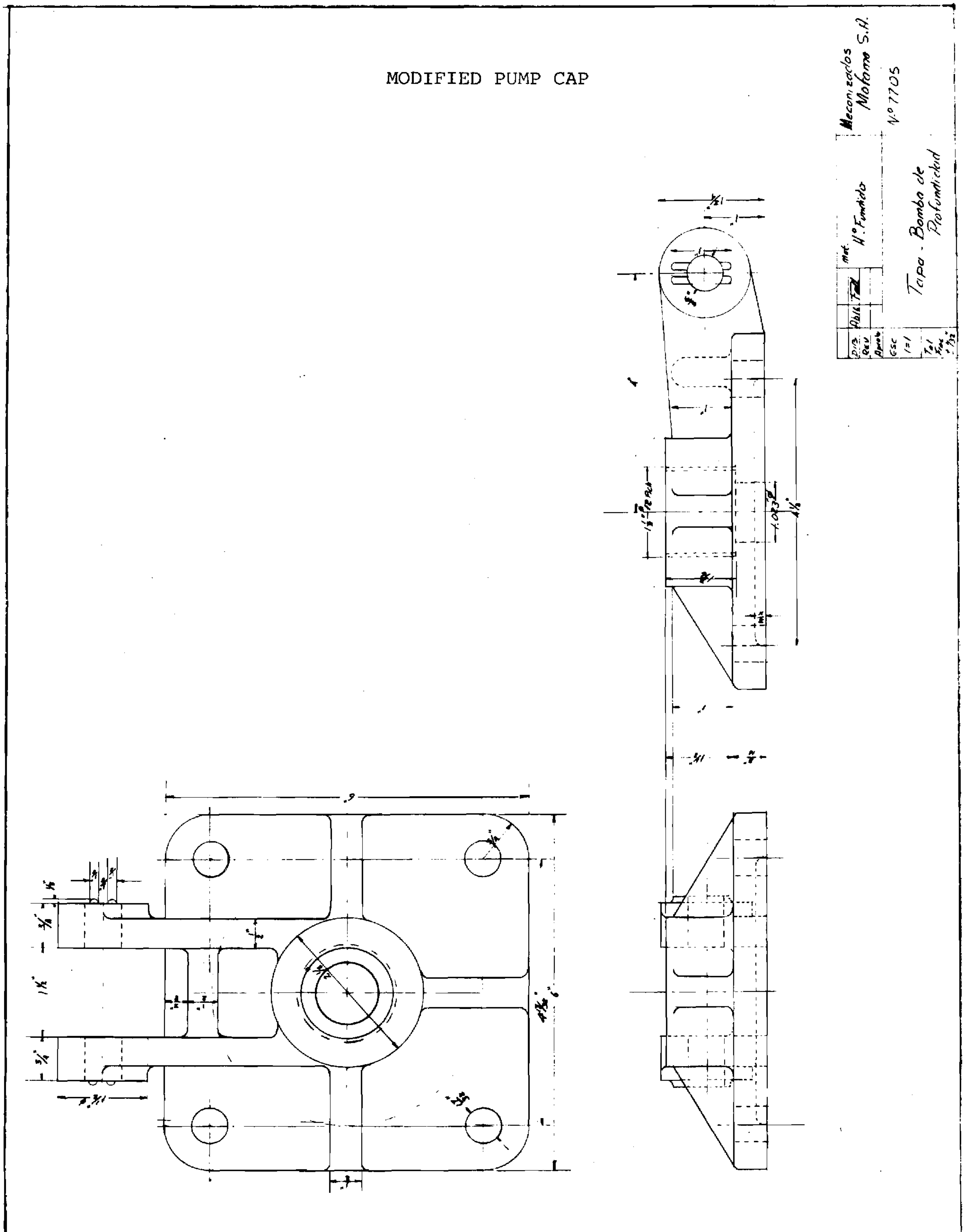
3. For the shallow-well pump, the three-inch support pipe was internally coated with epoxy for a smoother-surfaced cylinder finish. Option A (drawing No. 2001), using the bolted pump cap, was chosen in preference to a pin-mounted pump cap.

4. For the deep-well pump (drawing No. 2002), Option A was chosen, using the bolted pump cap in preference to a pin-mounted pump cap. The pump cap was modified, further (the following pages contain working drawings of the modifications), because of concern by the manufacturer that he could not cast this particular part. The pump cylinder was to be constructed from standard PVC pipe.

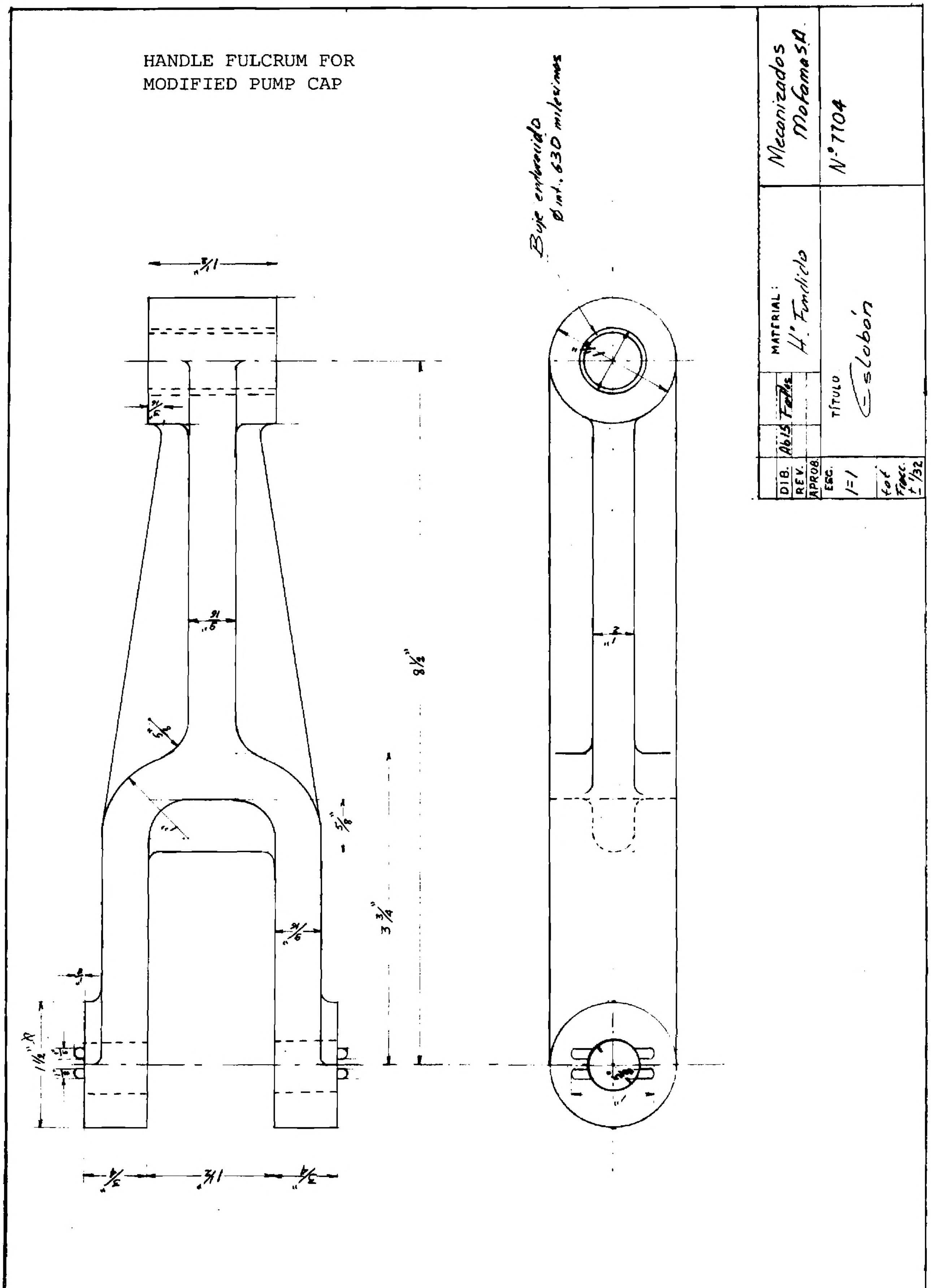
In addition to the above, all pumps were painted with an anticorrosive coating and consecutively numbered for identification purposes. Other than the pump cap, no unusual manufacturing problems were encountered besides those to be expected from unfamiliarity with the pump itself on the first production order. If a sample of the pump cap specified by the drawings had been available for the manufacturer, it is felt by this author that the manufacturer could have easily produced the proper cap.

It should be noted that the foundry producing the castings had no laboratory facilities and used scrap metal as the source of raw materials. High-quality castings require a level of technology not generally expected to be found in developing countries and, without this technology, quality (such as degree of hardness) will vary from pump to pump and from one production order

MODIFIED PUMP CAP



HANDLE FULCRUM FOR
MODIFIED PUMP CAP



to the next. The pump castings produced in Costa Rica appear to be rough in texture but adequate for that which they were intended.

Comparative Pumps

Two pumps were chosen for comparison with the AID pumps manufactured in Costa Rica, a Dempster 210F pump and a Japanese Kawamoto Daiichi "Lucky" pump. The Dempster model is considered one of the best pumps in the world, has the cylinder below water level so that it can be used for wells of shallow or deep depth, and costs approximately $257 in Central America, delivered (the $257 includes both the pump and the cylinder). The "Lucky" pump is for shallow wells only (25 feet or less, in depth), appears to be of good quality, has a porcelain-lined cylinder, and costs approximately $63 in Central America, delivered.

Field Test Sites

Table 1 shows those sites selected for the field testing in Costa Rica and which were chosen primarily because of their relative high usage and accessibility. All sites were existing wells, dug (rather than drilled), and were equally divided between deep wells (as used herein, more than 25 feet in depth) and shallow wells (25 feet or less in depth). The average site had been used by 75 persons and already had an existing pump, with the condition of the pump varying from broken and inoperable to good. The general areas of site concentration are in the northwestern quadrant of Costa Rica in the vicinity of Nicoya, Santa Cruz, Liberia, and Las Canas, and the eastern area of Limon (see Map 1).

Selection of the sites was made during the dry season months of January, February, and March so that the water column figures would indicate annual low-water levels. However, the dry season of 1976-1977 has taken its toll on the sites, and, by the middle of May, many of the sites had dried up completely and must be deepened before all pumps can be installed. In some cases, the wells have been dug as deeply as possible and now must either be drilled deeper, or substitute sites must be found.

By June 1, 1977, approximately one-half of the 30 test pumps had been installed without any significant problems, and the balance of the pumps has been scheduled for installation during the month of June. All installed pumps are functioning properly, and there are no obvious weaknesses that have

Table 1

SELECTED SITES FOR AID PUMP FIELD TESTS IN COSTA RICA

Site No.	Location	Well Situation	Well Type	Classification by Depth	Depth to Water (mt.)	Depth to Water (ft.)	Water Column (mt.)	Estimated Usage - No. Persons 30-60	61-100	>100	Type of Existing Pump	Condition of Existing Pump	Type of Pump to Install[3]
1	Margarita (schoolhouse)	Existing	Dug	Shallow	2.30	7½	1.70		X		None	--	AID-SW
2	Bristol (Square No. 1)	Existing	Dug	Shallow	2.20	7	0.90		X		None	--	Japanese
3	Bristol (Square No. 2)	Existing	Dug	Deep[1]	--	--	--			X	Dempster	Good	Dempster
4	Baltimor	Existing	Dug	Shallow	3.20	10	1.00	X			None	--	AID-SW
5	Corina	Existing	Dug	Shallow[2]	--	--	--	X			Japanese	Poor	AID-SW
6	Corina (schoolhouse)	Existing	Dug	Deep	7.60	25	1.00		X		Dempster	Good	Dempster
7	Zent (Sr. Pedro Bustos)	Existing	Dug	Shallow	2.60	8½	1.60	X			None	--	AID-SW
8	Zent (Sr. Mariano Grijado)	Existing	Dug	Shallow	2.95	9½	1.85	X			None	--	Japanese
9	Zent (schoolhouse)	Existing	Dug	Shallow	3.30	11	1.60	X			None	--	AID-SW
10	El Brillante	Existing	Dug	Deep[1]	--	--	--		X		Dempster	Fair	AID-DW
11	Judas de Chomes	Existing	Dug	Shallow	5.70	19	4.10		X		Dempster[4]	Poor	Japanese
12	La Palma de Abangares	Existing	Dug	Deep	11.00	36	0.75		X		Japanese	Broken	AID-DW
13	San Joaquin de Abangares	Existing	Dug	Deep	10.30	34	1.40	X			Dempster	Poor	AID-DW
14	Pueblo Nuevo de Abangares	Existing	Dug	Shallow	5.20	17	1.40	X			Dempster	Fair	Japanese
15	San Buena Ventura de Colorado	Existing	Dug	Deep	7.00	23	2.70		X		Dempster	Good	Dempster
16	Penas Blancas de Colorado	Existing	Dug	Shallow	5.95	19½	1.55		X		Dempster	Good	AID-SW
17	Nicoya (Barrio San Martin)	Existing	Dug	Deep[1]	--	--	--	X			Dempster	Good	Dempster
18	Curime de Nicoya	Existing	Dug	Deep	30.35	99½	1.00	X			Dempster[4]	Poor	Dempster
19	Caimitalito de Nicoya	Existing	Dug	Deep	8.95	29	1.60	X			Red Jacket	Broken	AID-DW
20	Conjunto IMAS, El Torito, Samara	Existing	Dug	Shallow	5.43	18	.43			X	Dempster	Good	Japanese
21	Terciopelo de Nicoya	Existing	Dug	Deep	7.23	24	1.04	X			Dempster	Poor	AID-DW
22	San Francisco de Santa Cruz	Existing	Dug	Deep	8.20	27	1.10	X			Dempster	Fair	Dempster
23	Hernandez de Santa Cruz	Existing	Dug	Shallow	2.45	8	1.85		X		Dempster	Good	Japanese
24	Villa Real de Santa Cruz No. 1	Existing	Dug	Deep[1]	--	--	--		X		Japanese	Poor	AID-DW
25	Villa Real de Santa Cruz No. 2	Existing	Dug	Deep	11.00	36	--		X		Dempster	Poor	Dempster
26	Villa Real de Santa Cruz No. 3	Existing	Dug	Deep[1]	--	--	--			X	Dempster	Fair	AID-DW
27	Los Pargos de Santa Cruz	Existing	Dug	Shallow	5.85	19	0.70	X			Dempster	Good	AID-SW
28	San Jose de Pinilla	Existing	Dug	Shallow	2.55	8	2.00			X	Dempster	Good	Japanese
29	Pijije de Bagaces	Existing	Dug	Deep	10.90	36	2.40	X			Dempster[4]	Good	Dempster
30	La Javilla de Canas (Puerto Canas)	Existing	Dug	Deep[1]	--	--	--	X			Dempster	Poor	AID-DW

[1]Assumed deep: well sealed, depth unknown.

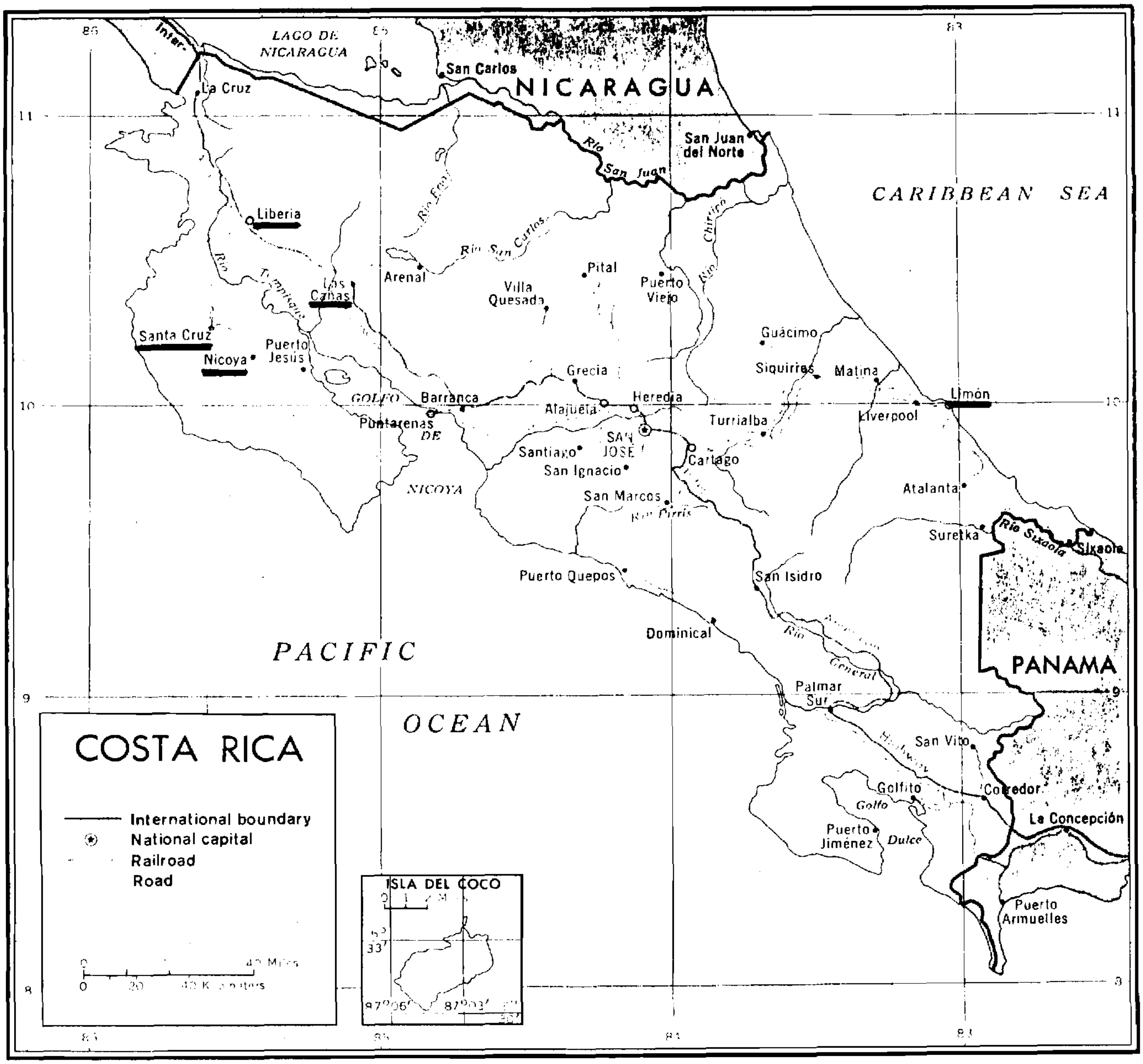
[2]Assumed shallow: well sealed, depth unknown.

[3]AID-DW: AID pump for deep well; AID-SW: AID pump for shallow well; Dempster: Dempster deep well type pump; Japanese: Japanese made shallow well type pump.

[4]Pump being used for forced pumping to storage tank.

Map 1

COSTA RICA



Sites in Costa Rica are concentrated in two major areas: (1) the northwestern quadrant around Nicoya, Santa Cruz, Liberia, and Las Canas, and (2) the eastern area of Limon.

COSTA RICA

Costa Rica Site No. 10, located at El Brillante, prior to installation of field test pump. Photo taken January, 1977.

Costa Rica Site No. 11, located at Judas de Chomes, prior to installation of field test pump. Photo taken January, 1977.

COSTA RICA

Costa Rica Site No. 24, located at Villa Real de Santa Cruz, prior to replacement of broken Japanese pump with field test pump. Photo taken January, 1977.

Costa Rica Site No. 15, located at San Buena Ventura de Colorado, prior to installation of field test pump. Photo taken January, 1977.

shown up in the first several months of operation. The AID pumps appear to be well designed and well manufactured, but the shallow-well type is not self-priming, a very disturbing factor from the standpoint of health. (In the next several months, efforts will be concentrated on designing a seal that will create enough of a vacuum to make the shallow-well pump self-priming.)

Water Quality

Water samples have been taken from 13 Costa Rican locations prior to installation of pumps to determine the level of bacteriological contamination in the water being used by rural villagers. All locations, except one, contain Escherichia coli in concentration ranging from 3.6 to 1,100 per 100 ml sample:

Site No.	Location	Total Coliforms 35° C	Escherichia coli 44° C
11	Judas de Chomes	210	150.0
12	La Palma de Abangares	1,100	460.0
13	San Joaquin de Abangares	460	21.0
14	Pueblo Nuevo de Abangares	1,100	290.0
15	San Buena Ventura de Colorado	460	240.0
16	Penas Blancas de Colorado	1,100	1,100.0
17	Nicoya (Barrio San Martin)	210	20.0
18	Curime de Nicoya	43	3.6
19	Caimitalito de Nicoya	1,100	120.0
20	Conjunto IMAS, El Torito, Samara	290	290.0
21	Terciopelo de Nicoya	0	0.0
29	Pijije de Bagaces	150	3.6
30	La Javilla de Canas	93	3.6

Inasmuch as the presence of E. coli indicates fecal contamination, ideally none should be present. It is not surprising to find this existing condition, however, due to the circumstances of the individual wells themselves. While the wells were properly disinfected at the time of their construction, imperfect sealing of the top, seepage of surface water, and other conditions have lead to subsequent contamination. Bacterial quantity is subject to considerable variability, and frequent analysis of each site would be required to provide definitive data; it is noteworthy, on the other hand, that there has been only one location free of coliforms.

Water disinfection has been a routine matter in Costa Rica prior to installation of pumps, but there has been no laboratory analysis to reveal the extent of assumed contamination in the wells. Because many of the sites in Costa Rica have been disinfected in the past and the wells were supposedly sealed off from contamination, only to result in continued contamination, the sites will also be tested periodically after pump installation to measure the effectiveness of pump programs such as this one now being carried out in Costa Rica and Nicaragua. In other words, if wells with hand-operated pumps installed on them have the advantage of an easier delivery system without an improvement in the quality of the water, the expenditures for the pumps hardly seem justifiable.

A chemical analysis is available at the present time from only one site, and it is obviously not possible to draw any general conclusions from such limited data. Nevertheless, when comparing the results from this one site (Bristol, Square No. 2) with the standards prescribed by the United States Public Health Service (USPHS), the water represented by the sample was found to be quite hard (199.0 ppm $CaCO_3$) and was within the USPHS limits on all items except iron (1.4 ppm reported, as compared to the standard of 0.30 ppm). While the iron is not a desirable condition, it is not a source of great concern other than from the standpoint of taste and, possibly, staining of laundry. Because more data are needed on chemical quality of the water represented by the field-test sites, further sampling of the water will be carried out during the remaining time period of the project.

NICARAGUA

Data from 1971 show that 53% of the total population of Nicaragua has relatively easy access to piped water supplies; however, when this figure is broken down into urban and rural areas, it is seen that 91% of the urban population has easy access to this type of water system, while only 18% of the rural population has easy access. Comparative figures for Costa Rica are 78% (total), 100% (urban), and 56% (rural). While these figures are somewhat outdated, it is felt that they probably have not changed significantly in the last six years.2/

Nicaragua was chosen as a test country for this program also because of a loan by AID to that country involving the installation of hand-operated water pumps. The loan provisions included a potable water program which will construct 300-340 wells by the end of 1979 and, which, as in the case of Costa Rica, the Georgia Tech/ICAITI program will complement, allowing the Ministry of Health in Nicaragua to take advantage of local manufacturing and its associated benefits.

Program activities also began in Nicaragua in January of this year. A local foundry was chosen to manufacture 20 AID pumps (eleven deep-well and nine shallow-well) which were produced and delivered to a Ministry of Health warehouse for storage, prior to installation, in May. Three kinds of pumps were chosen to compare the AID pump with: Dempster, a Brazilian Marumby pump, and a pump developed by the International Development Research Centre (IDRC) of Ottawa, Canada. Thirty sites, representative of Nicaragua, were approved to receive the test pumps (15 AID pumps and 15 comparative pumps), all of which required extensive preparatory work before pumps could be installed. Pumps are now being installed, and the wells are being disinfected with a chlorine-yielding substance. As in Costa Rica, the sites have had chemical and bacteriological testing prior to installation of test pumps and show intestinal bacteria, requiring further testing to determine if the contamination is being sealed out by the addition of a closed well and the use of a hand pump for lifting the water. The 12-month monitoring period has begun and will continue through July 1978.

2/ The Dynamics of Health, XI: Nicaragua, published by the U. S. Department of Health, Education, and Welfare, 1973.

Manufacture of AID Pumps

In manufacturing the AID pumps in Nicaragua, a unique situation was encountered, that is, foundries were plentiful, but pattern makers were almost nonexistent. A foundry was located that appeared to have the resources, including pattern makers, to manufacture a quality AID pump, and a contract was signed January 22, 1977, between Georgia Tech and Complejo Metalurgico Especializado, S.A. (Cometales) for the manufacture of eleven deep-well pumps and nine shallow-well pumps. The prices of the pumps were as follows:

Shallow-Well	$ 69 (each)
Deep-Well	75 (each)
Patterns	1,000 (one-time charge only)

Cost data are still being collected and analyzed to determine if these prices are sufficient to cover all expenses, including overhead, and to allow a reasonable profit for the manufacturer.

The AID pumps in Nicaragua were also manufactured according to the approved drawings contained in the appendix to this report and with the following additional instructions:

1. The plunger rod was to be made from one-half inch diameter rod, rather than seven-sixteenths inch, because of difficulty in locating a reliable supply of seven-sixteenths inch stock. The pump rod nut, the rod end, and the plunger assembly were also changed to accommodate the one-half inch plunger rod.

2. The handle pivot pins were to be hardened to 40 R_C, and steel bushings (60-64 R_C) were to be inserted in the pump handle holes.

3. For the shallow-well pump, the three-inch support pipe was internally coated with epoxy for a smoother-surfaced cylinder finish. Option A (drawing No. 2001), using the bolted pump cap, was chosen in preference to a pin-mounted pump cap.

4. For the deep-well pump (drawing No. 2002), Option A was chosen, using the bolted pump cap in preference to a pin-mounted pump cap. The AID pump manufacturer in Nicaragua neither foresaw nor experienced any problems with producing the deep-well pump cap in

accordance with specifications, in contrast to the case in Costa Rica.

All pumps were painted with an anticorrosive coating and were numbered consecutively. No unusual manufacturing problems were encountered other than unfamiliarity with the pump's characteristics for the first production order, and subsequent orders, if they should materialize, are not expected to present any difficulties.

Comparative Pumps

Three pumps were chosen for comparison with the AID pump and were locally available to the people of Nicaragua. These pumps include the Dempster 210F, a Brazilian Marumby pump (for shallow wells only), and a pump developed by IDRC (for shallow wells and deep wells). The Dempster 210F is designed for heavy-duty use in both shallow and deep wells, has a brass-lined cylinder, is made of cast iron, and has a very good worldwide reputation, as pointed out earlier. The Brazilian pump is for shallow wells only, uses a one-and-one-fourth-inch drop pipe (as do the Dempster and AID pumps), has a cylinder slightly over three inches (3.1") of smoothened, cast iron, and is a pitcher-type pump. The pump developed by IDRC uses a three-inch diameter drop pipe (PVC) that also serves as the cylinder for the piston assembly.

The Dempster 210F cost approximately $257 in Central America, the Brazilian Marumby approximately $45, and the IDRC pump $70 (this estimated $70 cost is for comparison only and can vary widely, depending on the materials and the pricing systems used by the fabricating shop). It is interesting, at this point, to recap all pumps included in the field testing of the AID pump:

	Costa Rica	Nicaragua
1. AID Shallow-Well (for shallow wells only)	$ 98	$ 69
2. Japanese "Lucky" (for shallow wells only)	63	--
3. Brazilian Marumby (for shallow wells only)	--	45
4. AID Deep-Well (for deep and shallow wells)	128	75
5. Dempster 210F (for deep and shallow wells)	257	257
6. IDRC PVC Cylinder (for deep and shallow wells)	--	70

Selection of Field Test Sites

Table 2 shows the sites selected for field testing in Nicaragua. Most of the wells were already existing, dug (there was one spring, Site No. 9, that has been adapted to support a pump), and have been equally divided between deep wells and shallow wells. Usage is quite high for the sites, averaging 150 persons, and all wells have required site work of some kind (well deepening, lining applied to the well, slab and other concrete work performed, and cleaning and disinfecting of the well). There are at least seven sites that pose problems demanding a search for substitute wells with the problems including the striking of hard rock during excavation, wells caving in, water sources polluted beyond present ability to correct, and villagers deciding that they would prefer an electric pump and storage tank to a hand-operated water pump (even if the villagers have to pay for the electric pump and storage tank).

Site Preparation

It was the original intent of this project to use existing wells with pumps that were inoperable or in a state of disrepair and to merely replace the broken pumps with the test pumps. This approach was impractical in Nicaragua because there are few existing hand-pump installations and most of those that do exist are privately owned, belonging to the more affluent rural villagers. Therefore, it was necessary to dig new wells, provide construction of well structures, and rehabilitate all wells before installation of any pumps. In addition to problems previously mentioned, many others have been encountered, including dissention among villagers as to where the new wells and pumps would be located, failure to find water at a reasonable depth, and lack of logistical resources within the country.

By June 1, 1977, pumps had been installed at approximately 15 sites. No significant problems have been encountered in the actual installation of these pumps, and all pumps are functioning properly. The balance of the 30 test pumps will be installed during June, and all pumps will be monitored through July 1978.

Table 2

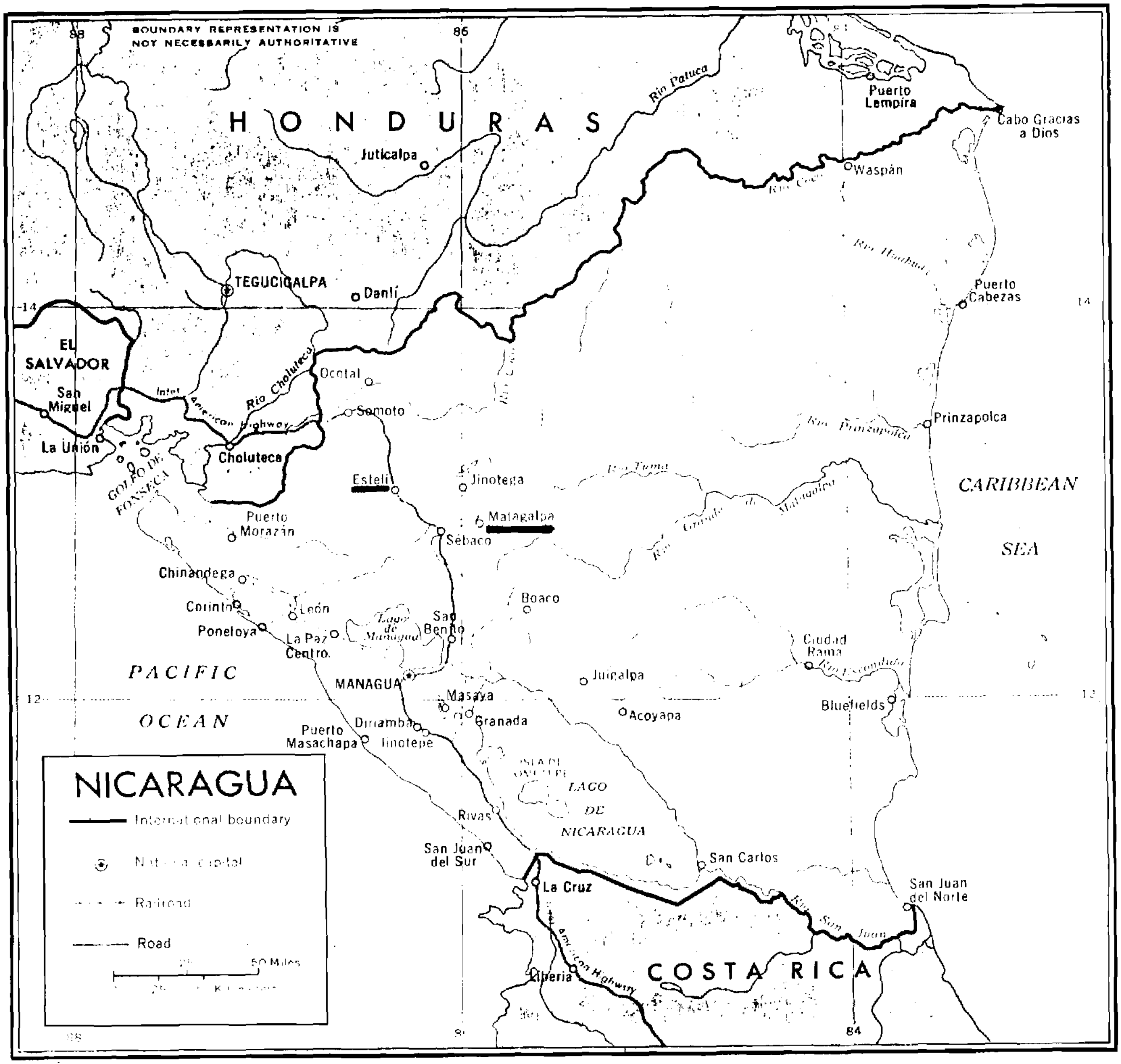
SELECTED SITES FOR AID PUMP FIELD TESTS IN NICARAGUA

Site No.	Location	Well Situation	Well Type	Classification by Depth	Depth to Water (mt.)	Depth to Water (ft.)	Water Column (mt.)	Well Diameter (mt.)	Estimated Usage (No. Persons) 50-100	101-150	>150	Site Work Required: New Well	Deepen Well	Lining	Slab	Disinfect	Install Pump	Type of Pump to Install[1]
1	La Garita (schoolhouse)	Existing	Dug	Deep	8.20	27	0.78	0.80	X				X		X	X	X	AID-DW
2	La Garita (highway)	New well required	Dug	Deep	--	--	--	--			X	X		X	X	X	X	Dempster
3	Llano Grande	Existing	Dug	Shallow	2.20	7½	1.77	1.20		X			X		X	X	X	AID-SW
4	Los Canas (highway)	Existing	Drilled	Deep	7.47	25	7.82	(6")		X						X	X	AID-DW
5	Los Canas (school)	Existing	Dug	Shallow	6.40	21	0.50	1.80	X				X		X	X	X	Braz.
6	Mechapa	Existing	Dug	Deep	17.80	58	0.95	1.23		X			X			X	X	Dempster
7	Las Lajitas	Existing	Dug	Shallow	5.40	18	0.45	1.45	X				X		X	X	X	AID-SW
8	Los Rastrojos	Under construction	Dug	Deep	12.00	39	2.00	1.20			X		X	X	X	X	X	AID-DW
9	El Naranjo	Existing	Spring	Shallow	2.12	7	1.00	2.0x2.0			X		X		X	X	X	Braz.
10	Isidrillo	Existing	Dug	Deep	24.10	79	2.00	1.20			X		X			X	X	AID-DW
11	Rio Abajo (Santa Teresa)	Existing	Dug	Shallow	3.50	11½	0.85	1.2x1.2			X		X			X	X	Braz.
12	Rio Abajo (Los Laureles)	Existing	Dug	Shallow	4.08	13	0.34	1.2x1.2		X			X			X	X	AID-SW
13	Quebrada Arriba	New well required	Dug	Shallow	--	--	--	--			X	X		X	X	X	X	Braz.
14	Los Rincones	Existing	Dug	Deep	19.20	63	1.00	1.20			X		X			X	X	AID-DW
15	Rio Grande	New well required	Dug	Shallow	--	--	--	--		X		X		X	X	X	X	Braz.
16	San Antonio	Existing	Dug	Deep	9.87	32	0.55	0.70			X		X	X	X	X	X	AID-DW
17	El Rodeo	Existing	Dug	Deep	15.91	52	0.33	1.20	X				X		X	X	X	Dempster
18	Los Calpules (stream)	Existing	Dug	Shallow	1.37	4½	1.18	1.20	X				X		X	X	X	AID-SW
19	Los Calpules (schoolhouse)	Existing	Dug	Deep	8.45	28	0.51	1.20			X		X		X	X	X	Dempster
20	Motolin (Sr. Umanzor)	Existing	Dug	Deep	15.56	41	0.42	1.00		X			X		X	X	X	Dempster
21	Ducuale Grande	New well required	Dug	Shallow	--	--	--	--		X		X		X	X	X	X	AID-SW
22	La Concepcion (No. 1)	Existing	Dug	Deep	--	--	--	--	X				X		X	X	X	Dempster
23	Valle Santa Rosa	Under construction	Dug	Deep	--	--	--	--		X			X	X	X	X	X	AID-DW
24	Sabana Grande	Existing	Dug	Deep	14.17	46½	0.23	0.91	X				X		X	X	X	AID-DW
25	San Diego	Existing	Dug	Deep	27.48	90	0.20	1.17		X			X			X	X	Dempster
26	La Lamilla	Under construction	Dug	Deep	14.00	46	1.80	1.20			X		X	X	X	X	X	Dempster
27	Valle Santa Lucia	Under construction	Dug	Shallow	--	--	--	--			X		X	X	X	X	X	AID-SW
28	Los Curritos	New well required	Dug	Shallow	--	--	--	--		X		X		X	X	X	X	Braz.
29	Las Mangas	Existing	Dug	Deep	8.76	29	5.90	1.09			X				X	X	X	Dempster
30	La Majadita	Existing	Dug	Shallow	6.15	20	0.80	1.00	X				X		X	X	X	Braz.

[1] AID-DW: AID pump for deep well; AID-SW: AID pump for shallow well: Dempster: Dempster deep well type pump; Braz.: Brazilian shallow well type.

Map 2

NICARAGUA



Sites in Nicaragua are concentrated in the northern part of the country, near Matagalpa and Esteli.

NICARAGUA

Nicaragua Site No. 2, located at La Garita. This spring has been replaced as a source of water by a nearby dug well and a field test pump. Photo taken January, 1977.

Nicaragua Site No. 6, located at Mechapa, prior to field test pump installation. Photo taken January, 1977.

NICARAGUA

Nicaragua Site No. 10, located at Isidrillo, prior to field test pump installation. Photo taken January, 1977.

Nicaragua Site No. 27, located at Valle Santa Lucia, during construction of well. Photo taken January, 1977

Water Quality

The results of chemical analyses of 19 sites are given in Table 3. For comparison, the limits established by the USPHS for drinking water are also included. In general, the water sampled is quite hard, and at Los Rastrojos (Site No. 8), it is extremely hard. Water at Los Rincones (Site No. 14) is given as a hardness of 70, but this may be in error if the high total solids content of the water (608 mg/l) is correct; therefore, this value of 70 is being verified by an additional analysis. The total solids content of all other samples is in an acceptable range with the notable exception of Los Rastrojos (Site No. 8) where the level of 1,600 mg/l is more than three times the preferred maximum, but, presumably, no better water source is available. Iron content exceeds the standard in 10 cases, and manganese was found to exceed the USPHS limit in six samples.

Nitrate levels are low with the single exception of Isidrillo (Site No. 10) where the reported nitrate level of 306.5 mg/l exceeds the 100 mg/l total solids. It appears likely that a clerical error has occurred, and this value is being rechecked. The levels of fluoride present may offer considerable resistance to tooth decay, as the recommended concentrations in the United States where water supplies are to be fluoridated are 0.7 - 1.2 mg/l, depending on the air temperature. Both chloride and sulfate are at sufficiently low concentrations.

An examination of the bacteriological data (Table 4) shows that all sites are significantly contaminated with common intestinal bacteria. Salmonella was initially reported at Los Laureles (Site No. 12), and this point has been rechecked. (A second sample was negative, but an additional analysis will be performed at a later date to determine if any continuing hazard is present.) All sites will be analyzed further during the next 12 months to provide more insight into whether or not contamination is being sealed off from the water by the preparation of the wells and the installation of the pumps.

Table 3

SUMMARY OF WATER CHEMICAL ANALYSES[a] -- NICARAGUA

Site No.	Location	pH	Hardness as $CaCO_3$	Alkalinity as HCO_3^-	Total Solids	Fe	Mn	Ca	NO_3^-	F	Cl	$SO_4^=$
1	La Garita	7.0	350	26	218	0.07	0.05	70.0	3.76	0.30	22.5	2.0
3	Llano Grande	6.4	200	120	161	0.07	0.00	30.0	9.96	0.70	12.5	3.0
6	Mechapa	7.7	325	30	330	0.06	0.00	80.0	13.10	0.40	12.5	8.0
7	Las Lajitas	7.5	200	190	225	0.02	0.40	50.0	4.43	0.35	5.0	2.0
8	Los Rastrojos	7.6	840	260	1,600	0.27	0.58	292.0	0.66	1.62	20.0	67.5
9	El Naranjo	6.9	400	420	426	0.05	0.00	100.1	3.54	0.70	15.0	3.0
10	Isidrillo	7.6	400	180	100	0.07	0.00	90.0	306.50	0.35	62.5	10.0
11	Santa Teresa	8.1	240	265	383	0.01	0.00	62.0	9.52	0.35	15.5	11.0
12	Los Laureles	7.7	250	265	340	0.01	0.00	64.0	6.42	0.60	15.0	6.0
13	Quebrada Arriba	7.5	180	280	360	0.10	0.28	44.1	1.76	0.20	15.0	8.3
14	Los Rincones	8.1	70	445	608	0.01	0.00	20.0	16.60	0.25	20.0	20.0
15	Rio Grande	8.0	190	250	336	0.25	0.28	52.1	4.80	0.20	25.0	10.5
16	San Antonio	7.9	240	270	404	0.01	0.00	68.0	2.65	0.50	19.5	11.0
18	Los Calpules (Stream)	7.9	290	330	394	0.01	0.10	80.0	0.00	0.55	10.0	2.0
19	Los Calpules (School)	7.9	210	200	237	0.01	0.00	50.0	5.10	0.60	12.5	4.0
20	Motolin	8.2	240	250	298	0.05	0.00	62.0	22.40	0.65	14.0	4.0
22	La Concepcion	7.5	350	30	264	0.00	0.10	80.0	0.00	0.40	10.0	3.0
25	San Diego	7.6	260	290	398	0.10	0.00	56.1	2.35	0.40	25.0	15.0
29	Las Mangas	6.4	100	100	38	0.02	0.00	20.0	2.21	0.50	15.0	2.0
USPHS Standard		---	---	---	500	0.03	0.05	--	45.00	(b)	250.0	250.0

(a) All values mg/l except pH.
(b) Limit depends on daily air temperature. Upper limits range from 0.8 to 1.7 mg/l.

Table 4

SUMMARY OF BACTERIOLOGICAL ANALYSIS -- NICARAGUA

Site No.	Location	Coliforms per 100 ml	Salmonella Presence	Shigella Presence	Comments
1	La Garita	2.4	Negative	Negative	Positive Enterobacter
3	Llano Grande	430.0	Negative	Negative	Positive Enterobacter and Citrobacter
6	Mechapa	1,100.0	Negative	Negative	Positive Proteus and Citrobacter
7	Las Lajitas	150.0	Negative	Negative	Positive Enterobacter
9	El Naranjo	1,100.0	Negative	Negative	Positive Enterobacter
10	Isidrillo	1,100.0	Negative	Negative	None
11	Rio Abajo (Santa Teresa)	24.0	Negative	Negative	Positive Enterobacter
12*	Rio Abajo (Los Laureles)	64.0	Positive	Negative	Positive Salmonella sp, Enterobacter, and Citrobacter
12*	Rio Abajo (Los Laureles)	350.0	Negative	Negative	Positive Escherichia coli
14	Los Rincones	54.0	Negative	Negative	Positive Pseudomonas
16	San Antonio	120.0	Negative	Negative	Positive Escherichia coli
17	El Rodeo	540.0	Negative	Negative	Positive Escherichia coli
18	Los Calpules	23.0	Negative	Negative	Positive Escherichia coli
19	Los Calpules	920.0	Negative	Negative	None
26	La Lamilla (replacing La Concepcion)	350.0	Negative	Negative	Positive Escherichia coli
30	La Majadita	64.0	Negative	Negative	Positive Escherichia coli

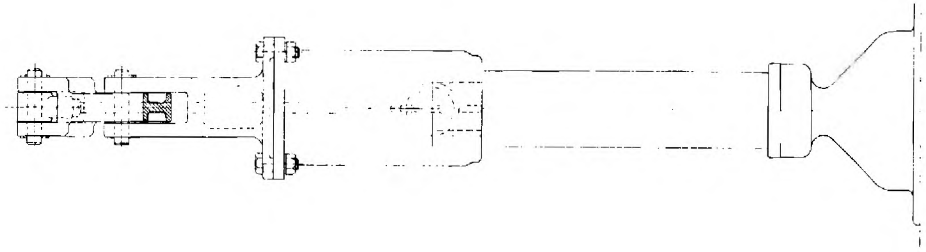
* This site (Los Laureles) was retested because of earlier findings of positive Salmonella. A third sampling is under way to verify the presence or absence of Salmonella.

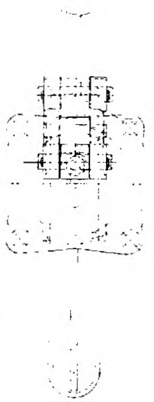
CONCLUSIONS AND RECOMMENDATIONS

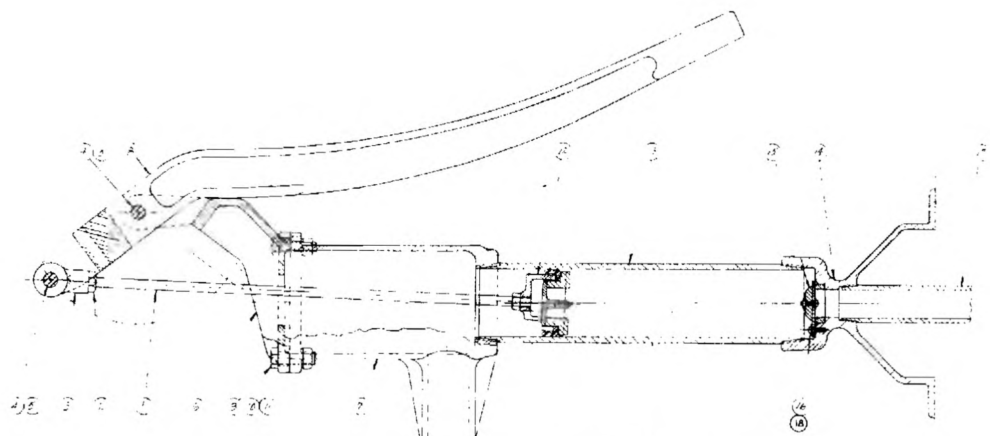
Monitoring of pump performance is in its early stages of the budgeted 12-month period, and sufficient data are not available for arriving at reliable conclusions. However, there are no indications at the present time that would discourage further manufacture, installation, or use of the AID pump in Costa Rica or Nicaragua. The AID pump can be manufactured in a developing country at a competitive, profitable price and at an acceptable level of quality if adequate facilities are available; however, the availability of adequate foundry facilities is a matter that must be determined for each individual developing country. Public acceptance by rural villagers has been good, both from an aesthetic standpoint and from a standpoint of the pump being used easily by men, women, and children. The AID pump is also very marketable if distribution channels and financial resources within the developing countries allow its purchase and installation, either by federal governments or by private citizens affluent enough to purchase and install the pump. Lastly, the AID pump should have a positive impact in developing countries on the health of rural people, on employment generation, and on instilling national pride within the people when it is seen that these countries do have local capabilities for manufacturing a complicated product rather than importing it.

Appendix A

AID-APPROVED PUMP DESIGN







OPTION A
VIEW SHOWING PUMP ON BASE
& BOLTED ON CAP

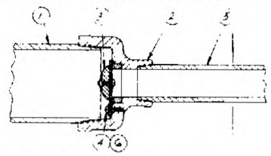
18	2	–	–	#10 PLAIN FLAT WASHER	BRASS	
17	AR	–	–	1¼ PIPE	ADD AT INSTALLATION	
16	2		–	MACHINE SCREW-ROUND BRASS	[illegible]	
15	1	[illegible]	B	CHECK VALVE ASSEM		
14	1	2010	[illegible]	PUMP STAND ASSEM		
13		2014	C	PUMP CYLINDER	3" SCHEDULE 40 PIPE (COATED)	
12	1	2009	B	PLUNGER ASSEM. SINGLE CUP		
11	4	–	–	LOCK WASHER	[illegible]	
10	4	–	–	NUT [illegible]	[illegible]	
9	4	–	–	BOLT [illegible]	[illegible]	
8	1	2008	E	HANDLE	CAST IRON	
7	1	2007	D	PUMP BODY	CAST IRON	
6	1	2006	D	PUMP CAP	CAST IRON	
5	4	–	–	COTTER PIN [illegible]	[illegible]	
4	2	2005	A	PIVOT PIN	⅝ x 3	
3		2004	B	ROD END	CAST IRON	
2	2		–	PUMP ROD NUT HEX	7/16-14 [illegible]	
1	1	2003	A	PLUNGER ROD	[illegible]	
FIND NO	QTY	PART NO OR IDENTIFYING NO	DWG SIZE	DESCRIPTION	SPECIFICATION	NOTE NO.

PARTS LIST

NOTE:
ASSEMBLY OF PUMP BODY, PIPE & PUMP STAND MUST BE TIGHT WITH AT LEAST 3" THREAD ENGAGEMENT AT EACH JOINT.

OPTION C

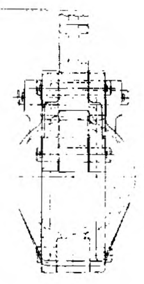
VIEW SHOWING LOWER VALVE HOUSING MOUNT DIRECTLY TO WELL PIPE.

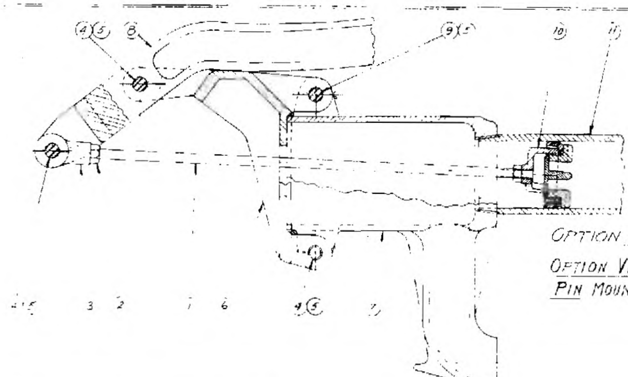


NOTE:
ALL PARTS ABOVE PUMP CYLINDER ARE IDENTICAL TO THOSE SHOWN IN VIEW OF PUMP SHOWN ABOVE OR BELOW.

6	2	–	–	#10 PLAIN FLAT WASHER	BRASS	
5	A.R.	–	–	1¼ PIPE	ADD AT INSTALLATION	
4	2	–	–	MACHINE SCREW-ROUND BRS	10-24 x [illegible]	
3	1	[illegible]	B	CHECK VALVE ASSEM		
2	1	[illegible]	[illegible]	LOWER VALVE HOUSING ASSEM		
1	1	2014	–	PUMP CYLINDER	3" SCHEDULE 40 PIPE (COATED)	
FIND NO	QTY	PART NO OR IDENTIFYING NO	DWG SIZE	DESCRIPTION	SPECIFICATION	NOTE NO

PARTS LIST





OPTION B

OPTION VIEW OF PUMP WITH PIN MOUNTED CAP

NOTE:
ALL PARTS BELOW PUMP CYLINDER ARE IDENTICAL TO THOSE SHOW IN EITHER OF TWO VIEWS SHOWN ABOVE.

11	1	2014	B	PUMP CYLINDER	3" SCHEDULE 40 PIPE (COATED)	
10	1	2009	B	PLUNGER ASSEM. SINGLE CUP		
9	1	[illegible]	A	CAP PIN	[illegible]	
8	1	2008	E	HANDLE	CAST IRON	
7	1	2012	D	PUMP BODY	CAST IRON	
6	1	2011	D	PUMP CAP	CAST IRON	
5	3	–	–	COTTER PIN (EXTENDED PRONG)	[illegible]	
4	3	2005	A	PIVOT PIN	[illegible]	
3	1	2004	B	ROD END	CAST IRON	
2	2	–	–	PUMP ROD NUT HEX	7/16-14 [illegible]	
1	1	2003	A	PLUNGER ROD	[illegible]	
FIND NO.	QTY	PART NO OR IDENTIFYING NO	DWG SIZE	DESCRIPTION	SPECIFICATION	NOTE NO

PARTS LIST

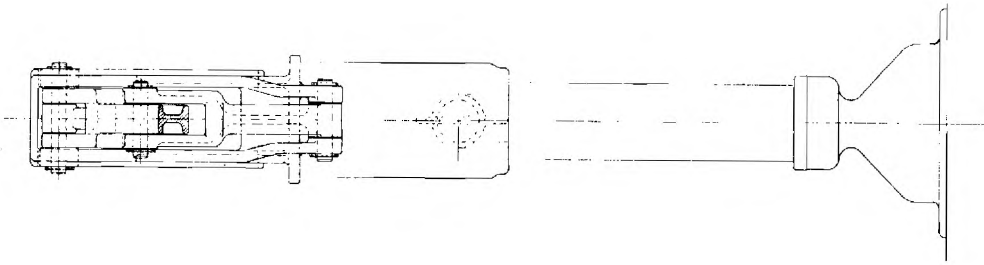
APPLICATION				DO NOT SCALE DRAWING	SIGNATURE	DIV.	DATE
THIS ITEM IS USED ON SUBASSEMBLIES				UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES. TOLERANCES ARE XX = XXXX = XXX = ANGLES =	DRAWN BY [signature]	[illegible]	[illegible]
DRAWING NO.	PER ASSY	NO. OF ASSYS	TOTAL	MATERIAL AND TREATMENT	DRAFTING APPR.		
					DESIGN APPR.		
					APPD		
					APPD		
TO MAKE FINAL ASSEMBLY			TOTAL REQ'D.		PROJECT APPR		
					SPECIAL APPR		

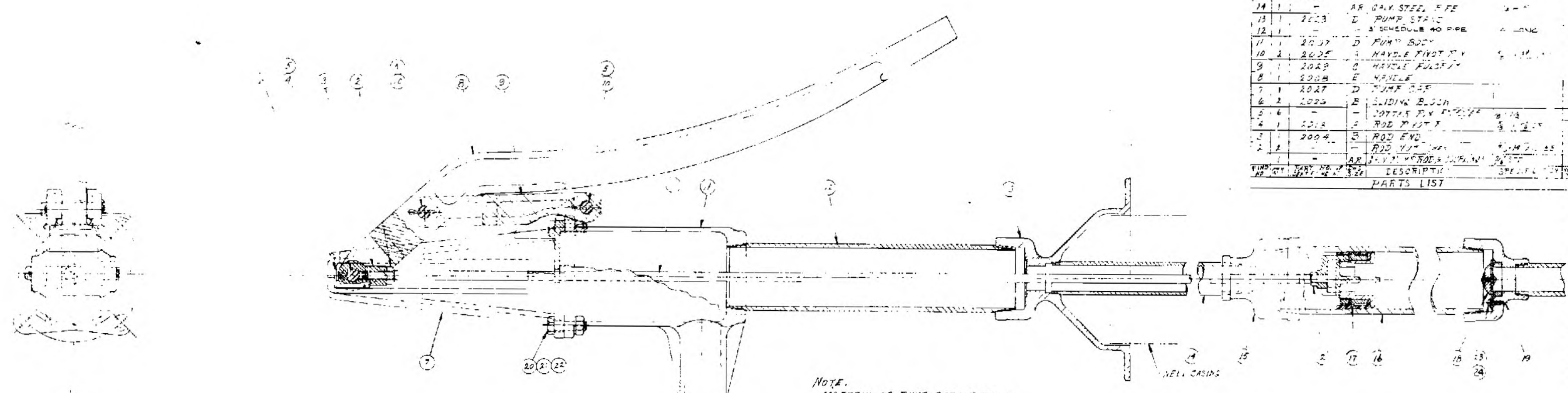
Battelle
Columbus Laboratories
505 King Avenue
Columbus, Ohio 43201
Telephone (614) 299-3151

TITLE
HAND PUMP ASSEMBLY
SHALLOW WELL TYPE

SIZE	CODE IDENT NO.	DIV NO.	DWG. NO.	REV.
E	79986	644	2001	
SCALE [illegible]	ACCT G1320-1		SHEET 1 OF	

DWG NO 2001



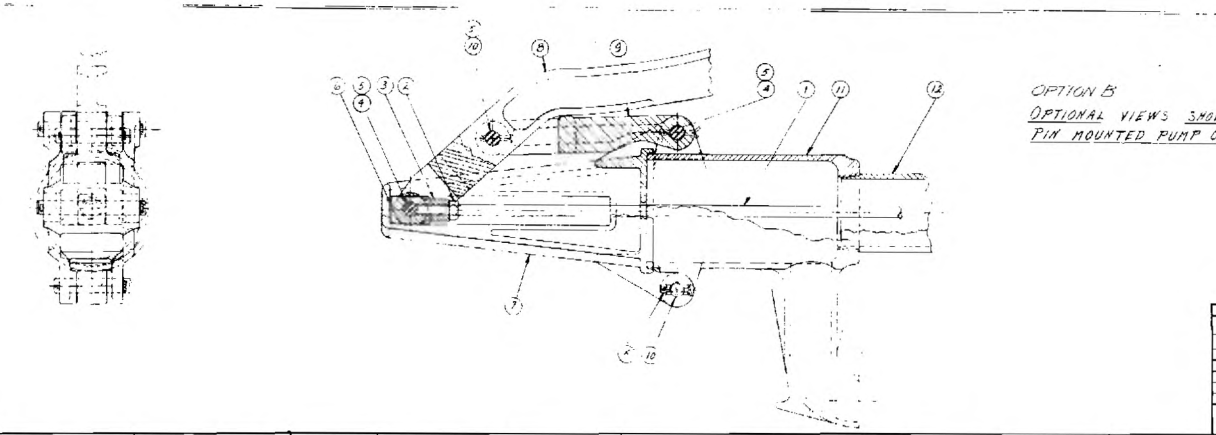


NOTE.
ASSEMBLY OF PUMP BODY, PIPE & PUMP STAND MUST BE TIGHT WITH AT LEAST $\frac{1}{2}$ THREAD ENGAGEMENT AT EACH JOINT.

OPTION A
VIEWS SHOWING BOLTED PUMP CAP

FIND NO	QTY	PART NO. OR IDENTIFYING NO	DWG. SIZE	DESCRIPTION	SPECIFICATION	NOTE NO
24	1		–	#10 PLAIN FLAT WASHER	BRASS	
23	2	–	–	MACHINE SCREW RD. HD. BRASS	10-24 x [illegible]	
22	4		–	LOCK WASHER	[illegible]	
21	4	–	–	NUT HEX	[illegible]	
20	4		–	BOLT HEX HD.	[illegible]	
19	1	2016	C	LOWER VALVE HOUSING		
18	1	[illegible]	B	CHECK VALVE ASSY.		
17	1	2030	C	PLUNGER ASSEM.		
16	1	20[illegible]4	C	PUMP CYLINDER	3" SCHEDULE 40 PIPE (INC. COATED)	
15	1	2025	C	CYLINDER END CAP		
14	1	–	AR	GALV. STEEL PIPE	[illegible]	
13	1	2023	D	PUMP STAND		
12	1	–	–	3" SCHEDULE 40 PIPE	[illegible] LONG	
11	1	2037	D	PUMP BODY		
10	2	2035	A	HANDLE PIVOT PIN	[illegible]	
9	1	2029	C	HANDLE FULCRUM		
8	1	2008	E	HANDLE		
7	1	2027	D	PUMP CAP		
6	2	2026	B	SLIDING BLOCK		
5	6	–	–	COTTER PIN [illegible]	[illegible]	
4	1	2013	A	ROD PIVOT PIN	[illegible]	
3	1	2004	B	ROD END		
2	2	–	–	ROD NUT HEX	[illegible]	
1		–	A.R.	GALV. PUMP ROD & COUPLING	[illegible]	

PARTS LIST



OPTION B
OPTIONAL VIEWS SHOWING PIN MOUNTED PUMP CAP.

NOTE.
ALL PARTS NOT SHOWN BELOW ARE THE SAME AS LISTED IN ASSEMBLY ABOVE

FIND NO	QTY	PART NO. OR IDENTIFYING NO	DWG. SIZE	DESCRIPTION	SPECIFICATION	NOTE NO
12	1	–	–	3" SCHEDULE 40 PIPE	[illegible]" LONG	
11	1	2017	D	PUMP BODY		
10	2	2035	A	PIN	[illegible]	
9	1	2029	C	HANDLE FULCRUM		
8	1	2008	E	HANDLE		
7	1	2028	D	PUMP CAP		
6	2	2026	B	SLIDING BLOCK		
5	8	–	–	COTTER PIN (EXTENDED PRONG)	[illegible]	
4	2	2013	A	PIVOT PIN	[illegible]	
3	1	2004	B	ROD END		
2	2	–	–	ROD NUT HEX	[illegible]	
	1	–	A.R.	GALV. PUMP ROD & COUPL.	[illegible]	

PARTS LIST

APPLICATION				DO NOT SCALE DRAWING	SIGNATURE	DIV	DATE
THIS ITEM IS USED ON SUBASSEMBLIES				UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES. TOLERANCES ARE	[illegible]	[illegible]	[illegible]
DRAWING NO	PER ASSY	NO. OF ASSYS	TOTAL	.XX = .XXXX =	DRAFTING APPD.		
				.XXX = ANGLES =	DESIGN APPD.		
				MATERIAL AND TREATMENT	APPD		
					APPD		
TO MAKE FINAL ASSEMBLY			TOTAL REQ'D		PROJECT APPD		
					SPECIAL APPD		

Battelle
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Columbus, Ohio 43201
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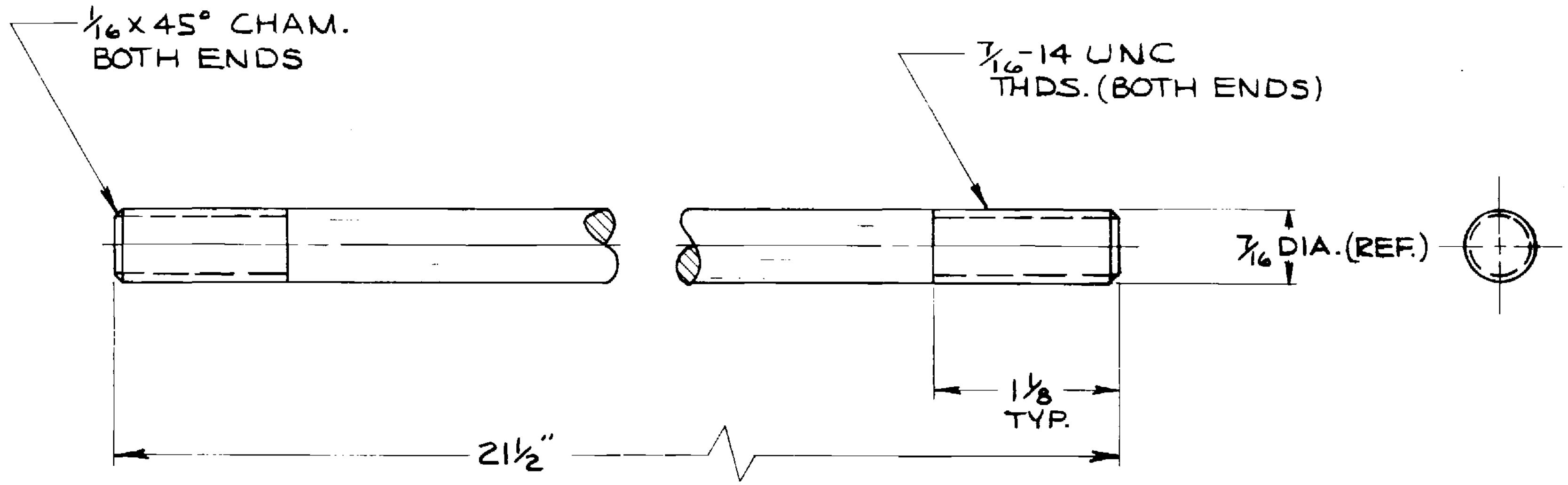
TITLE
HAND PUMP ASSEMBLY
DEEP WELL TYPE

SIZE	CODE IDENT NO	DIV NO.	DWG. NO.	REV
E	79986	[illegible]	2002	

SCALE [illegible] | ACCT [illegible]-320-1 | SHEET OF [illegible]

DWG NO 2002

REVISIONS			
LTR	DESCRIPTION	DATE	APPROVED



APPLICATION

THIS ITEM IS USED ON SUBASSEMBLIES

DRAWING NO.	PER ASSY	NO. OF ASSYS	TOTAL
2001	1	1	1

TO MAKE FINAL ASSEMBLY | TOTAL REQ'D.

DO NOT SCALE DRAWING

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES. TOLERANCES ARE: ±1/32

.XX = – .XXXX = –
.XXX = – ANGLES = ±1/2°

MATERIAL & TREATMENT

7/16 DIA. GALV.
PUMP ROD

SIGNATURE	DIV.	DATE
DRAWN BY	6[illegible]	1-7-7[illegible]
DRAFTING APPD.		
DESIGN APPD.		
APPD.		
PROJECT APPD.		
SPECIAL APPD.		

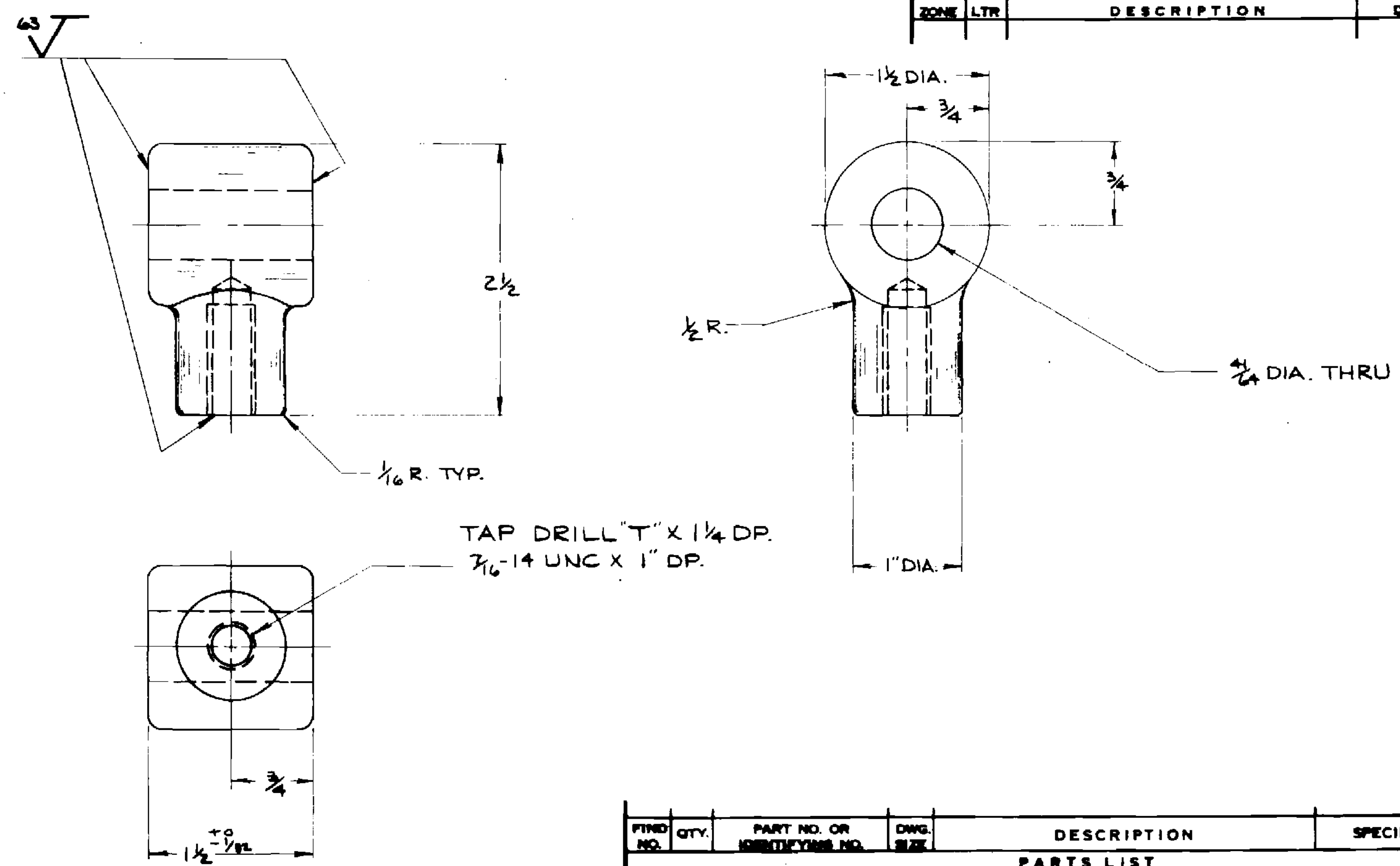
BATTELLE MEMORIAL INSTITUTE
COLUMBUS LABORATORIES
505 KING AVE., COLUMBUS, OHIO 43201

TITLE: PLUNGER ROD

SIZE	CODE IDENT. NO.	DIV. NO.	DWG. NO.	REV.
A	79986	644	2003	

SCALE 1" = 1" | ACCT. G1320-1 | SHEET 1 OF 1

CAT. 294163 FORM D-5 5-70



NOTES:

1. ALL DRAFT ANGLES TO BE 1½° TO 4°
2. ALL FILLETS & RADII TO BE ⅛" R. UNLESS OTHERWISE SPECIFIED

REVISIONS				
ZONE	LTR	DESCRIPTION	DATE	APPROVED

FIND NO.	QTY.	PART NO. OR IDENTIFYING NO.	DWG. SIZE	DESCRIPTION	SPECIFICATION	NOTE NO.

PARTS LIST

APPLICATION	
THIS ITEM IS USED ON ASSEMBLIES	
DRAWING NO.	
2001	
2002	
TO MAKE FINAL ASSEMBLY	TOTAL REQ'D.

MATERIAL & TREATMENT: CAST IRON

SIGNATURE	DIV.	DATE
DRAWN BY		
DRAFTING APPD.		
DESIGN APPD.		
APPD.		
PROJECT APPD.		
SPECIAL APPD.		

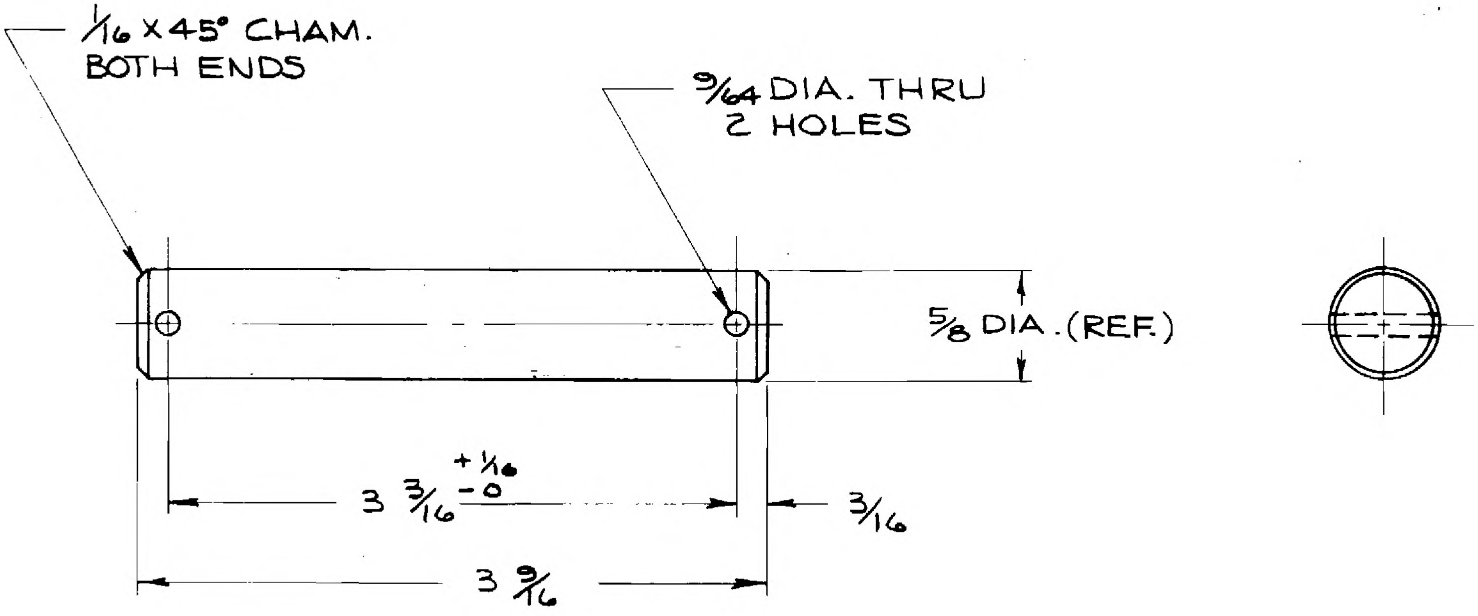
Battelle Columbus Laboratories

TITLE: ROD END

SIZE	CODE IDENT. NO.	DIV. NO.	DWG. NO.
B	79986	644	2004

SCALE 1" = 1" ACCT. G1320-1 SHEET 1 OF 1

REVISIONS			
LTR	DESCRIPTION	DATE	APPROVED



APPLICATION

THIS ITEM IS USED ON ASSEMBLIES

DRAWING NO.	PER ASSY	NO. OF ASSYS	TOTAL
2002	2	1	2
2001 "A"	2	1	2
2001 "B"	3	1	3

TO MAKE FINAL ASSEMBLY — TOTAL REQ'D.

DO NOT SCALE DRAWING

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES. TOLERANCES ARE: ±1/32

.XX = — .XXXX = —

.XXX = — ANGLES = ±1/2°

MATERIAL & TREATMENT

5/8 DIA. C.R.S. ROUND

SIGNATURE	DIV.	DATE
DRAWN BY [signature]	659	1-7-74
DRAFTING APPD.		
DESIGN APPD.		
APPD.		
PROJECT APPD.		
SPECIAL APPD.		

BATTELLE MEMORIAL INSTITUTE
COLUMBUS LABORATORIES
505 KING AVE., COLUMBUS, OHIO 43201

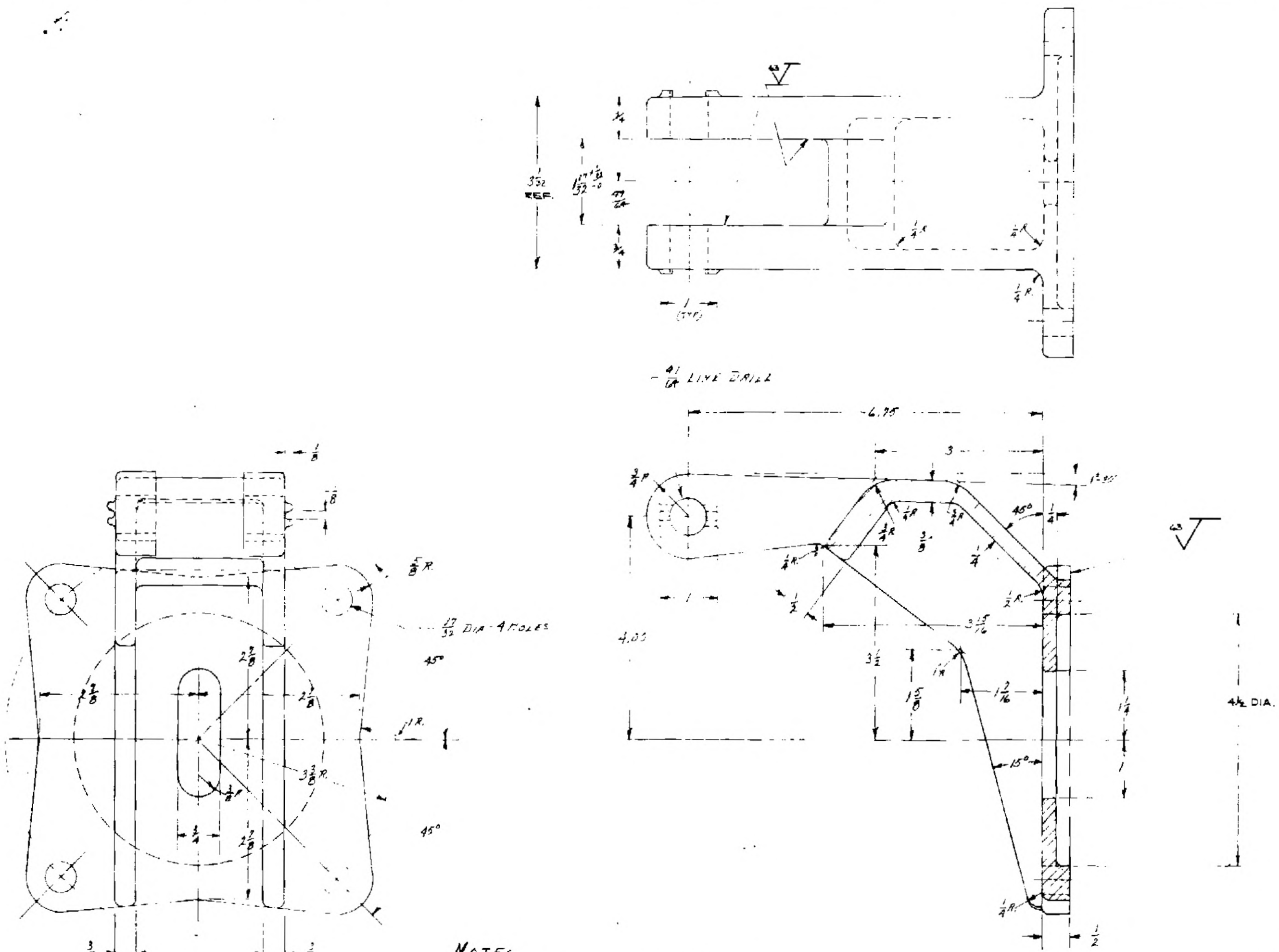
TITLE: HANDLE PIVOT PIN

SIZE	CODE IDENT. NO.	DIV. NO.	DWG. NO.	REV.
A	79986	644	2005	

SCALE 1" = 1" ACCT. G1320-1 SHEET 1 OF 1

CAT. 294163 FORM D-5 5-70

REVISIONS				
ZONE	LTR.	DESCRIPTION	DATE	APPROVED



NOTES:
1. ALL DRAFT ANGLES TO BE $1\frac{1}{2}°$ TO 4°
2. ALL RADII & FILLETS TO BE $\frac{1}{8}$ UNLESS OTHERWISE SPECIFIED

FIND NO.	QTY.	PART NO. OR IDENTIFYING NO.	DWG. SIZE	DESCRIPTION	SPECIFICATION

PARTS LIST

APPLICATION			
THIS ITEM IS USED ON SUBASSEMBLIES			
DRAWING NO.	PER ASSY	NO. OF ASSYS	TOTAL
2001	1	1	1
TO MAKE FINAL ASSEMBLY			TOTAL REQ'D.

DO NOT SCALE DRAWING
UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES. TOLERANCES ARE: ± $\frac{1}{32}$
.XX = ± .02 .XXXX = –
.XXX = – ANGLES = ± $\frac{1}{2}°$
MATERIAL AND TREATMENT
CAST IRON

SIGNATURE	DIV.	DATE
DRAWN BY C. [illegible]	653	4/30/74

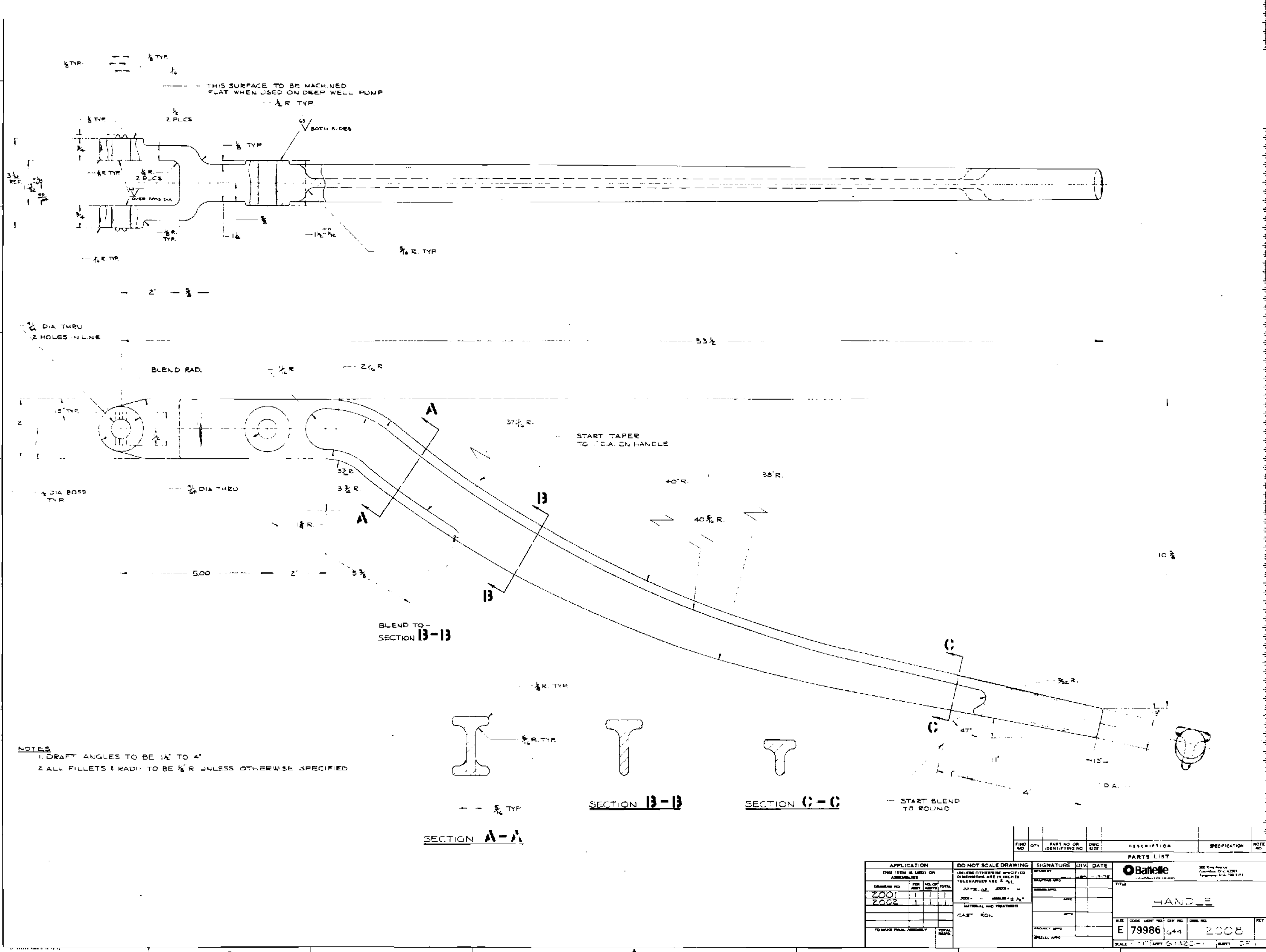
Battelle Columbus Laboratories

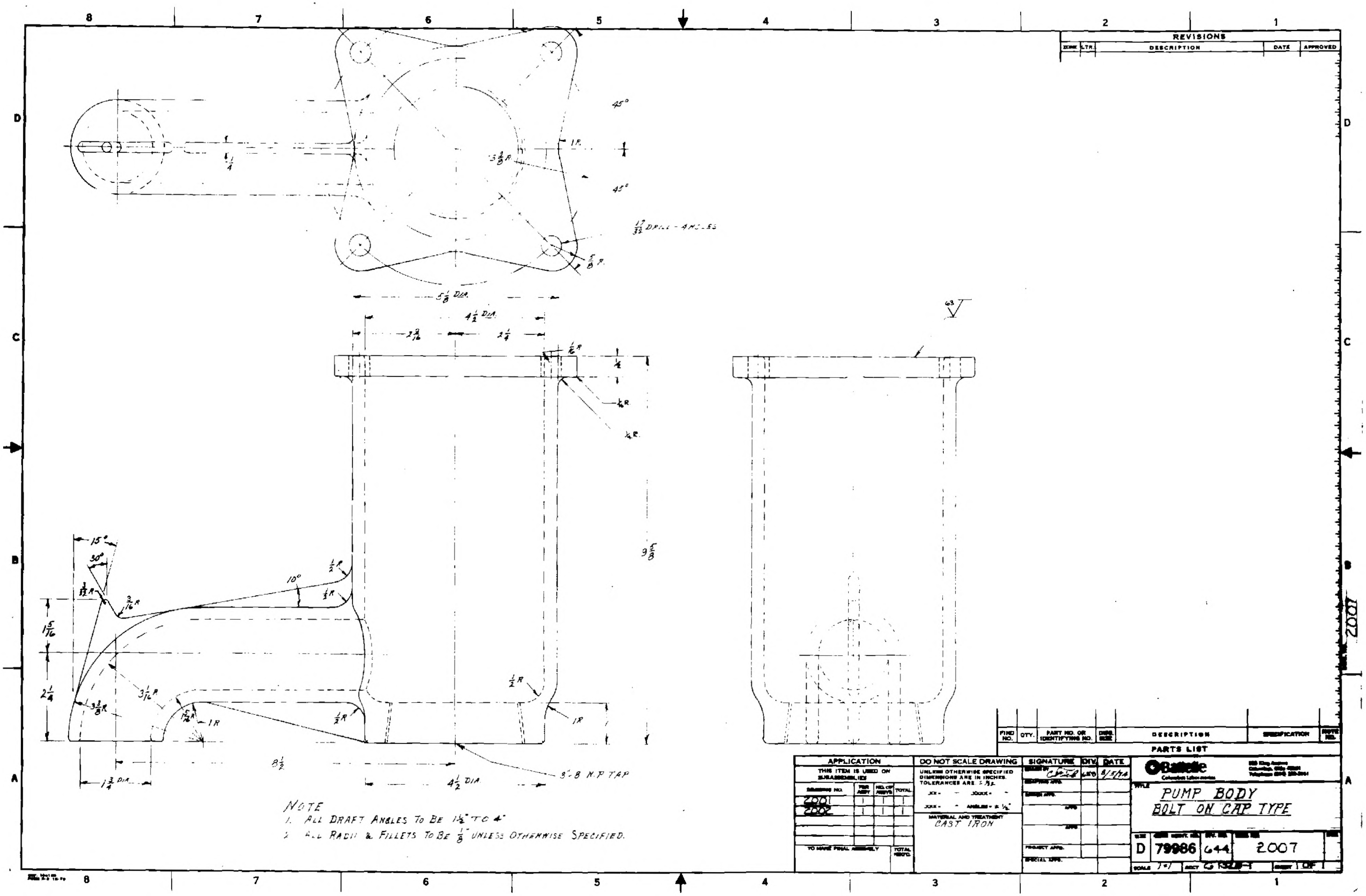
TITLE PUMP CAP SHALLOW WELL PUMP BOLT ON TYPE

SIZE			DWG. NO.
D	79986	644	2006

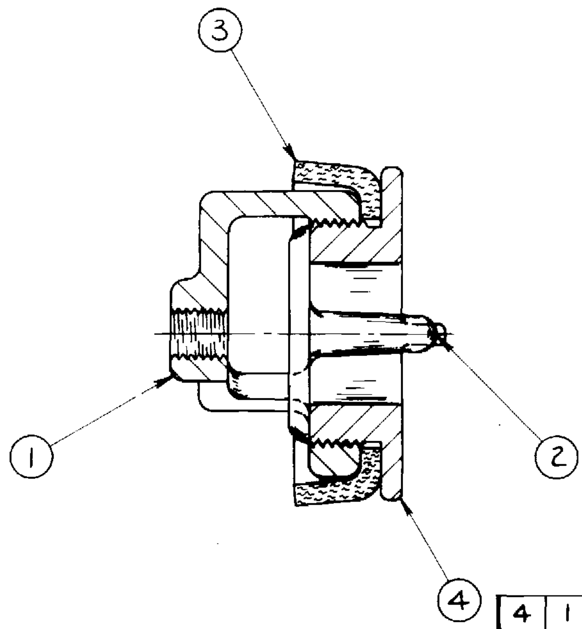
SCALE 1=1 ASSY. G1520-1 SHEET 1 OF 1

2006


THIS SURFACE TO BE MACHINED FLAT WHEN USED ON DEEP WELL PUMP
BOTH SIDES
DIA THRU 2 HOLES IN LINE
BLEND RAD.
START TAPER TO 1 DIA. ON HANDLE
DIA BOSS TYP.
DIA THRU
BLEND TO SECTION B-B
NOTES
1. DRAFT ANGLES TO BE 1½° TO 4°
2. ALL FILLETS & RADII TO BE ⅛ R UNLESS OTHERWISE SPECIFIED
SECTION A-A
SECTION B-B
SECTION C-C
START BLEND TO ROUND
APPLICATION
DO NOT SCALE DRAWING
UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES
2001
2002
CAST IRON
PARTS LIST
Battelle
HANDLE
E
79986
2008


REVISIONS
ZONE | LTR. | DESCRIPTION | DATE | APPROVED
45°
1R.
$3\frac{3}{8}$R.
45°
$\frac{17}{32}$ DRILL - 4 HOLES
$\frac{5}{8}$ R.
$5\frac{1}{8}$ DIA.
$4\frac{1}{2}$ DIA.
$2\frac{9}{16}$
$2\frac{1}{4}$
$\frac{1}{8}$R
$\frac{1}{2}$
$\frac{1}{16}$R
$\frac{1}{4}$R.
63
$9\frac{5}{8}$
15°
30°
10°
$\frac{1}{2}$R
$1\frac{5}{16}$
$2\frac{1}{4}$
$3\frac{1}{16}$R
$3\frac{3}{8}$R
1R
$8\frac{1}{2}$
$1\frac{3}{4}$ DIA.
$4\frac{1}{2}$ DIA.
3/8 N.P. TAP
NOTE
1. ALL DRAFT ANGLES TO BE $1\frac{1}{2}$° TO 4°
2. ALL RADII & FILLETS TO BE $\frac{1}{8}$ UNLESS OTHERWISE SPECIFIED.
FIND NO. | QTY. | PART NO. OR IDENTIFYING NO. | DWG. SIZE | DESCRIPTION | SPECIFICATION | NOTE NO.
PARTS LIST
APPLICATION
THIS ITEM IS USED ON SUBASSEMBLIES
2001
2002
TO MAKE FINAL ASSEMBLY
DO NOT SCALE DRAWING
UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES. TOLERANCES ARE ± 1/32
MATERIAL AND TREATMENT
CAST IRON
SIGNATURE | DIV. | DATE
8/5/74
Battelle
Columbus Laboratories
PUMP BODY
BOLT ON CAP TYPE
D
79986
644
2007
SCALE 1=1
SHEET 1 OF 1

REVISIONS				
ZONE	LTR	DESCRIPTION	DATE	APPROVED



FIND NO.	QTY.	PART NO. OR IDENTIFYING NO.	DWG. SIZE	DESCRIPTION	SPECIFICATION	NOTE NO.
4	1	2020	B	PLUNGER FOLLOWER SINGLE CUP		
3	1	2019	A	THREE INCH CUP		
2	1	2018	A	PLUNGER POPPET		
1	1	2017	B	PLUNGER CAGE		

PARTS LIST

APPLICATION

THIS ITEM IS USED ON ASSEMBLIES

DRAWING NO.: 2001

TO MAKE FINAL ASSEMBLY

DO NOT SCALE DRAWING

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES TOLERANCES ARE:

.XX = .XXXX =

.XXX= ANGLES=

MATERIAL & TREATMENT

SIGNATURE | DIV | DATE

DRAWN BY

DRAFTING APPD.

DESIGN APPD.

APPD.

PROJECT APPD.

SPECIAL APPD.

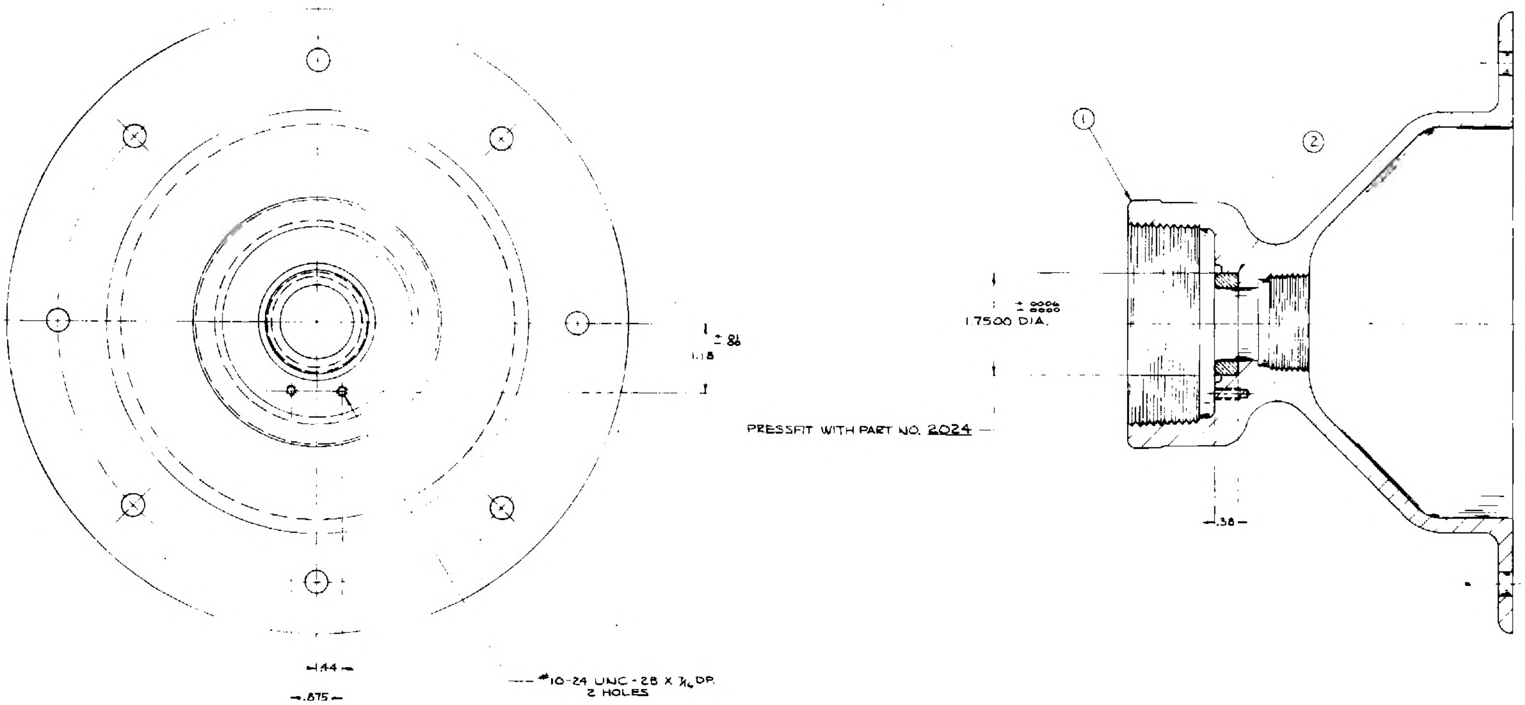
Battelle Columbus Laboratories

TITLE: THREE INCH PLUNGER ASSY. SINGLE CUP

SIZE: B | CODE IDENT. NO.: 79986 | DIV. NO.: 644 | DWG. NO.: 2009 | REV.

SCALE: " = 1" | ACCT. G1320-1 | SHEET 1 OF 1

CAT. 924100 FORM D-7 10-70



REVISIONS

ZONE	LTR.	DESCRIPTION	DATE	APPROVED

FIND NO.	QTY.	PART NO. OR IDENTIFYING NO.	DWG. SIZE	DESCRIPTION	SPECIFICATION	ITEM NO.
2	1	2024	A	BRASS VALVE SEAT		
1	1	2023	D	PUMP STAND		

PARTS LIST

APPLICATION

THIS ITEM IS USED ON ASSEMBLIES

DRAWING NO.	PER ASSY	NO. OF ASSYS	TOTAL
2001	1	1	1

TO MAKE FINAL ASSEMBLY — TOTAL REQ'D.

DO NOT SCALE DRAWING

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES. TOLERANCES ARE

XX = ± .01 XXXX = —

XXX = ± .005 ANGLES = —

MATERIAL AND TREATMENT

SIGNATURE | DIV. | DATE

DRAWN BY — 1-18-78

DRAFTING APPS.

DESIGN APPS.

APPS.

APPS.

PROJECT APPS.

SPECIAL APPS.

Battelle
Columbus Laboratories

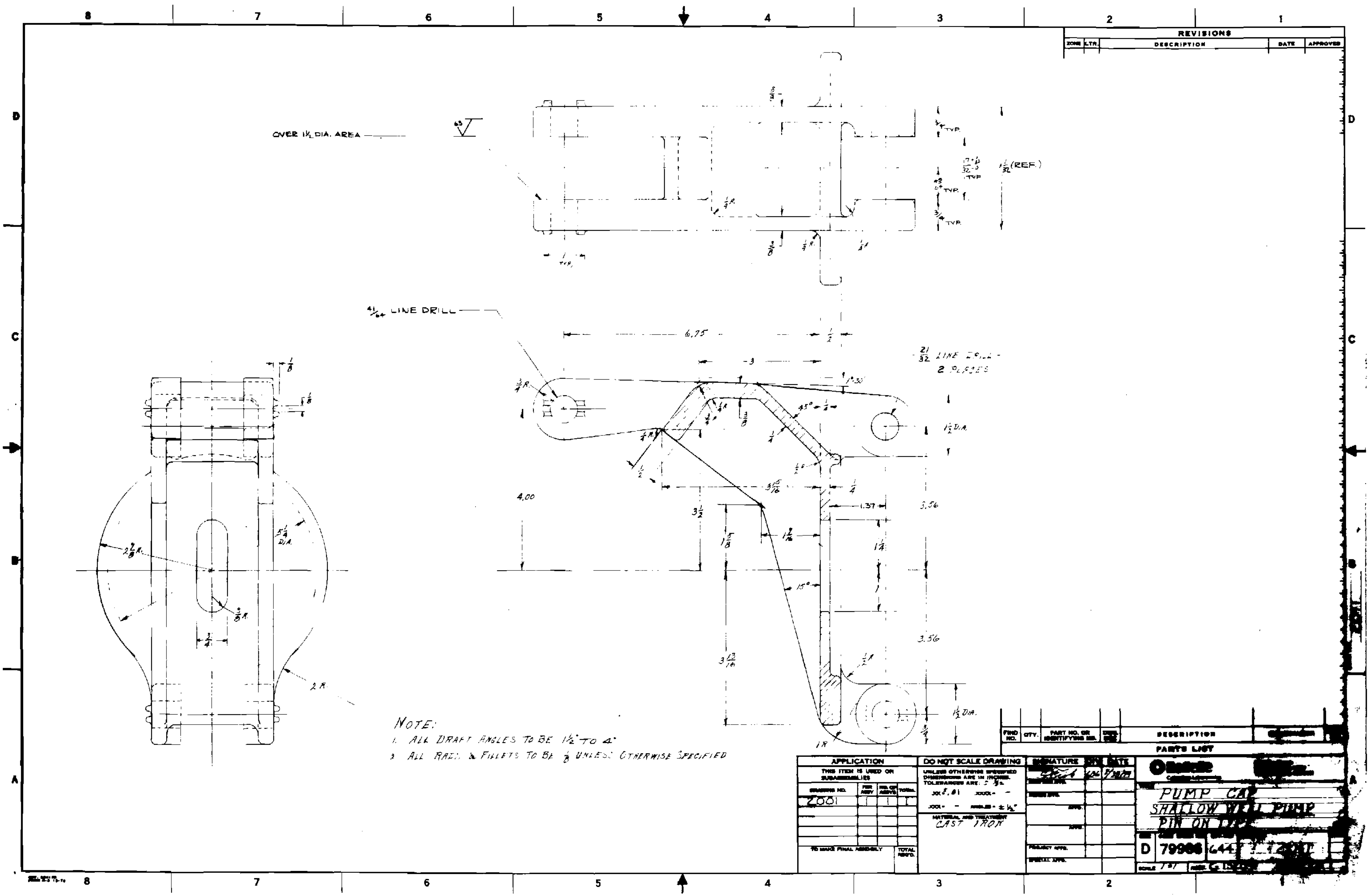
TITLE

PUMP STAND ASSY.

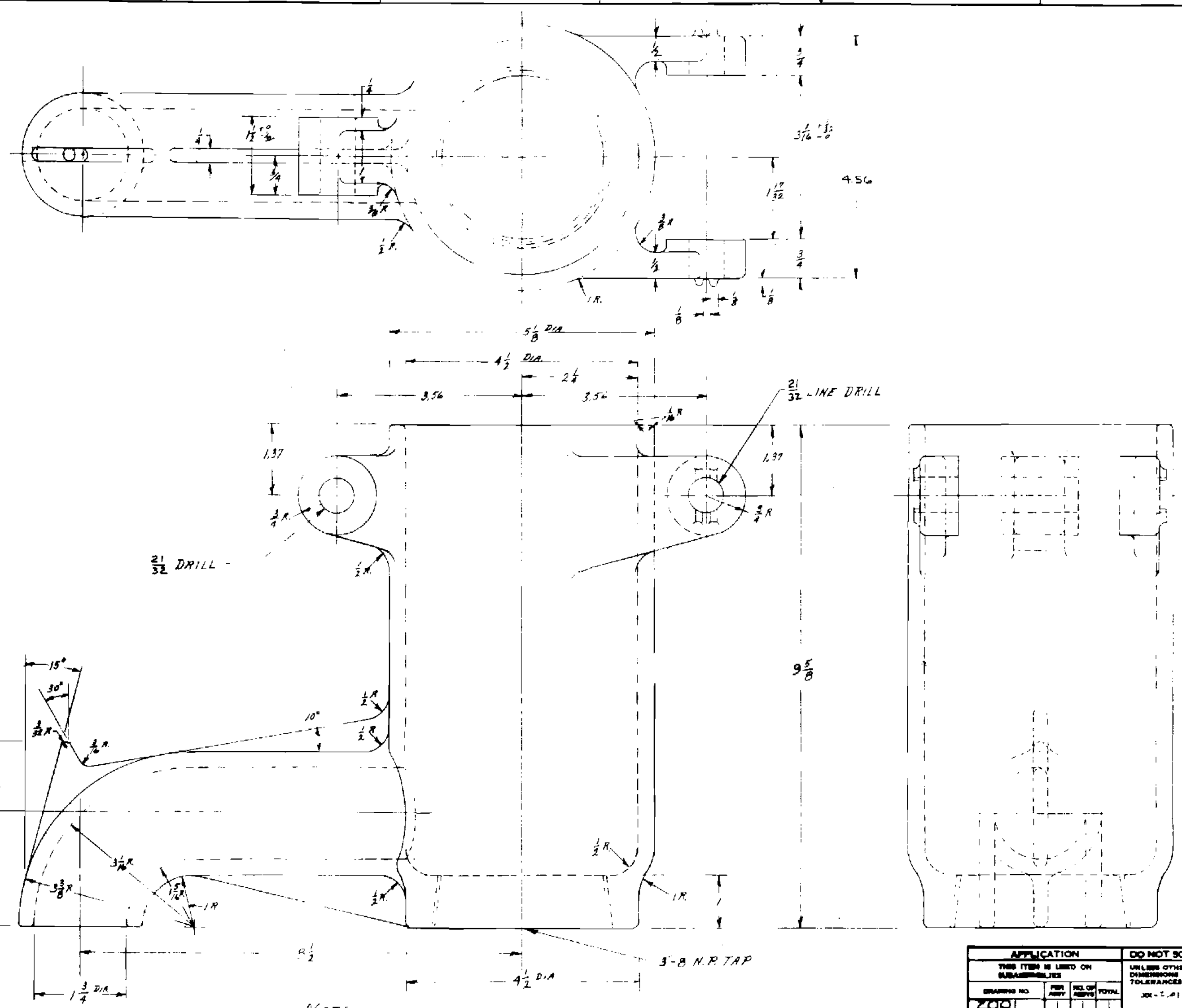
SIZE D | CODE IDENT. NO. 79986 | 644 | DWG. NO. 2010

SCALE 1"=1" | ACCT. G1320-1 | SHEET 1 OF 1

2010



REVISIONS
ZONE
LTR.
DESCRIPTION
DATE
APPROVED
OVER 1½ DIA. AREA
41/64 LINE DRILL
21/32 LINE DRILL
2 PLACES
6.75
4.00
3.56
1.37
NOTE:
1. ALL DRAFT ANGLES TO BE 1½° TO 4°
2. ALL RADII & FILLETS TO BE 1/8 UNLESS OTHERWISE SPECIFIED
FIND NO.
QTY.
PART NO. OR IDENTIFYING NO.
DESCRIPTION
PARTS LIST
APPLICATION
THIS ITEM IS USED ON SUBASSEMBLIES
DRAWING NO.
PER ASSY
NO. OF ASSYS
TOTAL
Z001
TO MAKE FINAL ASSEMBLY
TOTAL REQ'D.
DO NOT SCALE DRAWING
UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES.
MATERIAL AND TREATMENT
CAST IRON
SIGNATURE
DATE
PROJECT APPR.
SPECIAL APPR.
PUMP CAP
SHALLOW WELL PUMP
PIN ON TYPE
D
79986



NOTE:
1. ALL DRAFT ANGLES TO BE 1½° TO 4°
2. ALL RADII & FILLETS TO BE ¼ UNLESS OTHERWISE SPECIFIED.

REVISIONS

ZONE	LTR	DESCRIPTION	DATE	APPROVED

PARTS LIST

FIND NO.	QTY.	PART NO. OR IDENTIFYING NO.		DESCRIPTION	SPECIFICATION

APPLICATION

DRAWING NO.	PER ASSY	NO. OF ASSYS	TOTAL
2001			
2002			

DO NOT SCALE DRAWING

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES

MATERIAL AND TREATMENT: CAST IRON

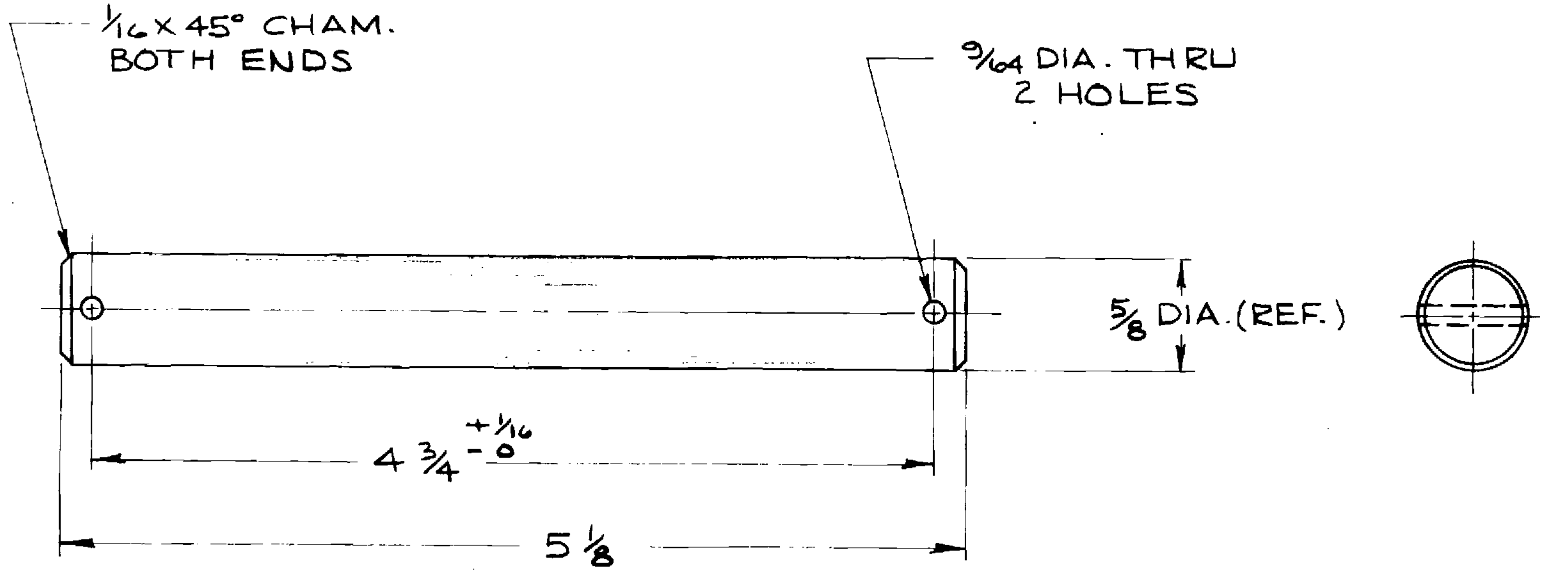
Battelle

PUMP BODY
PIN ON CAP TYPE

D 79986 644 2012

SCALE 1/1

REVISIONS			
LTR	DESCRIPTION	DATE	APPROVED



APPLICATION			
THIS ITEM IS USED ON SUBASSEMBLIES			
DRAWING NO.	PER ASSY	NO. OF ASSYS	TOTAL
2001 "B"	1	1	1
2002 "A"	1	1	1
2002 "B"	2	1	2
TO MAKE FINAL ASSEMBLY			TOTAL REQ'D.

DO NOT SCALE DRAWING

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES. TOLERANCES ARE: ± 1/32

.XX = .XXXX = –

.XXX = – ANGLES = ± 1/2°

MATERIAL & TREATMENT

5/8 C.R.S. ROUND

SIGNATURE	DIV.	DATE
DRAWN BY [illegible]	659	1-7-75
DRAFTING APPD.		
DESIGN APPD.		
APPD.		
PROJECT APPD.		
SPECIAL APPD.		

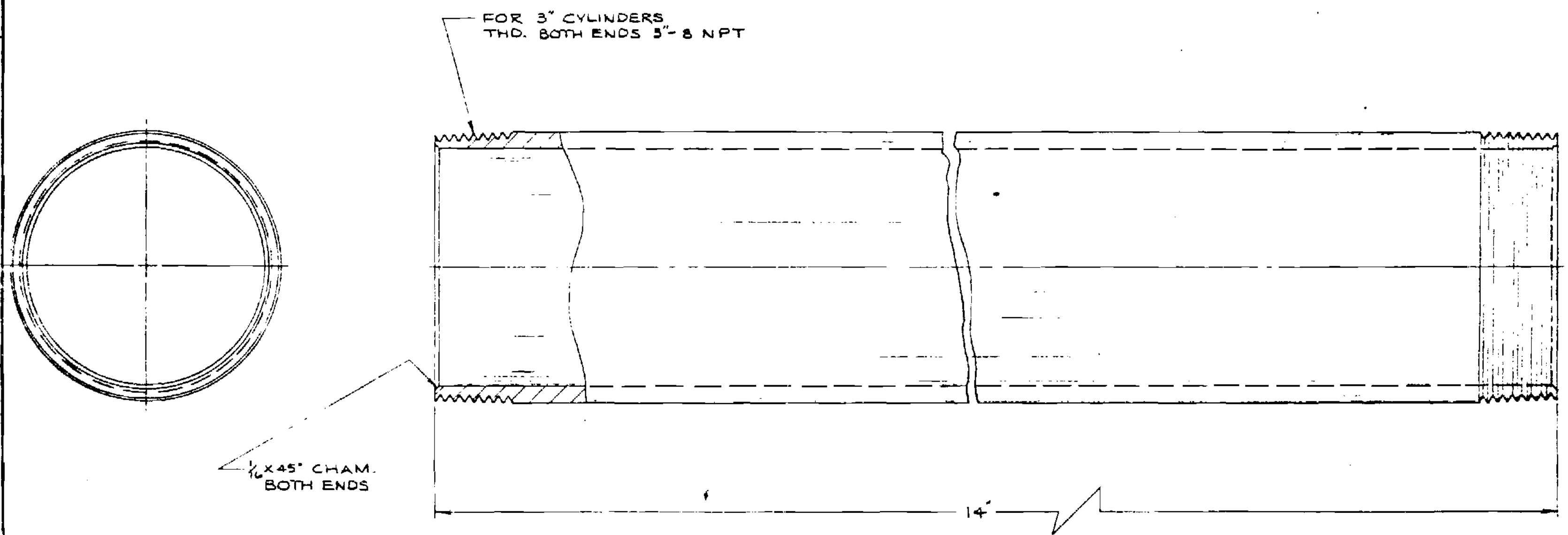
BATTELLE MEMORIAL INSTITUTE
COLUMBUS LABORATORIES
505 KING AVE., COLUMBUS, OHIO 43201

TITLE ROD PIVOT PIN

SIZE	CODE IDENT. NO.	DIV. NO.	DWG. NO.	REV.
A	79986	644	2013	

SCALE 1" = 1" ACCT. G 1320-1 SHEET 1 OF 1

CAT. 294163 FORM D-5 5-70



NOTE:

PIPE MAY BE MADE OF EITHER OF THE FOLLOWING MATERIALS FOR 3" CYLINDERS.

*1ST OPTION - STD. P.V.C. 1120 PLASTIC PIPE (SCH. 40)

2ND OPTION - STD. BLACK STEEL PIPE (SCH. 40) COATED WITH $.004^{+.004}_{-.000}$ THICKNESS OF SYNTHETASINE 200 (STONER - MUDGE) OR EQUIVALENT, ON ENTIRE SURFACE

3RD OPTION - STD. BLACK STEEL PIPE (SCH. 40) COATED WITH 2 COATS OF SOVAPON HI-BUILD EPOXY (MOBILE CHEMICAL CO.) OR EQUIVALENT OVER PRIMER

* PVC PIPE NOT TO BE USED IN SHALLOW WELL PUMP ASS'Y.

REVISIONS

ZONE	LTR	DESCRIPTION	DATE	APPROVED

PARTS LIST

FIND NO.	QTY.	PART NO. OR IDENTIFYING NO.	DWG. SIZE	DESCRIPTION	SPECIFICATION	NOTE NO.

APPLICATION

THIS ITEM IS USED ON ASSEMBLIES

DRAWING NO.	PER ASSY	NO. OF ASSYS	TOTAL
2001	1	1	1
2002	1	1	1

TO MAKE FINAL ASSEMBLY — TOTAL REQ'D.

DO NOT SCALE DRAWING

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES. TOLERANCES ARE: ± 1/32

.XX = — .XXXX = —
.XXX = — ANGLES = —

MATERIAL AND TREATMENT: NOTED

SIGNATURE	DIV.	DATE
DRAWN BY	655	1-14-74
DRAFTING APPD.		
DESIGN APPD.		
APPD.		
APPD.		
PROJECT APPD.		
SPECIAL APPD.		

Battelle Columbus Laboratories
505 King Avenue
Columbus, Ohio 43201
Telephone (614) 299-3151

TITLE: PUMP CYLINDER

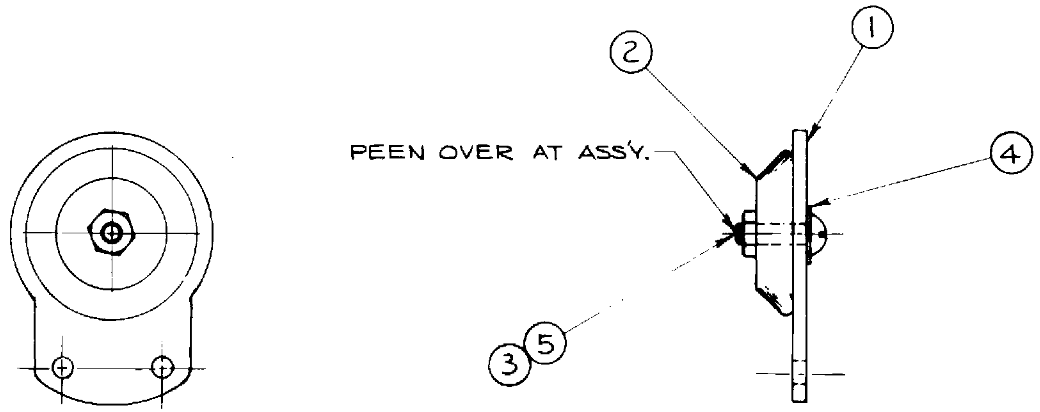
SIZE	CODE IDENT. NO.	DIV. NO.	DWG. NO.	REV.
C	79986	644	2014	

SCALE 1" = 1" ACCT. G 1320-1 SHEET 1 OF 1

DWG. NO. 2014

CAT. 204167 FORM 8-8 12-72

REVISIONS				
ZONE	LTR	DESCRIPTION	DATE	APPROVED



FIND NO.	QTY.	PART NO. OR IDENTIFYING NO.	DWG. SIZE	DESCRIPTION	SPECIFICATION	NOTE NO.
5	1	–	–	#10 NC-28 HEX NUT	BRASS	
4	1	–	–	#10 PLAIN FLAT WASHER	BRASS	
3	1	–	–	#10-24 NC-2A X 3/4 LONG RD. HD. SCR.	BRASS	
2	1	2022	A	CHECK VALVE WEIGHT		
1	1	2021	B	VALVE FLAPPER		

PARTS LIST

APPLICATION			
THIS ITEM IS USED ON ASSEMBLIES			
DRAWING NO.			
2001	1	1	1
2002	1	1	1
TO MAKE FINAL ASSEMBLY			TOTAL REQ'D.

DO NOT SCALE DRAWING
UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES. TOLERANCES ARE:
.XX = .XXXX =
.XXX= ANGLES=

MATERIAL & TREATMENT

SIGNATURE	DIV	DATE
DRAWN BY		
DRAFTING APPD.		
DESIGN APPD.		
APPD.		
PROJECT APPD.		
SPECIAL APPD.		

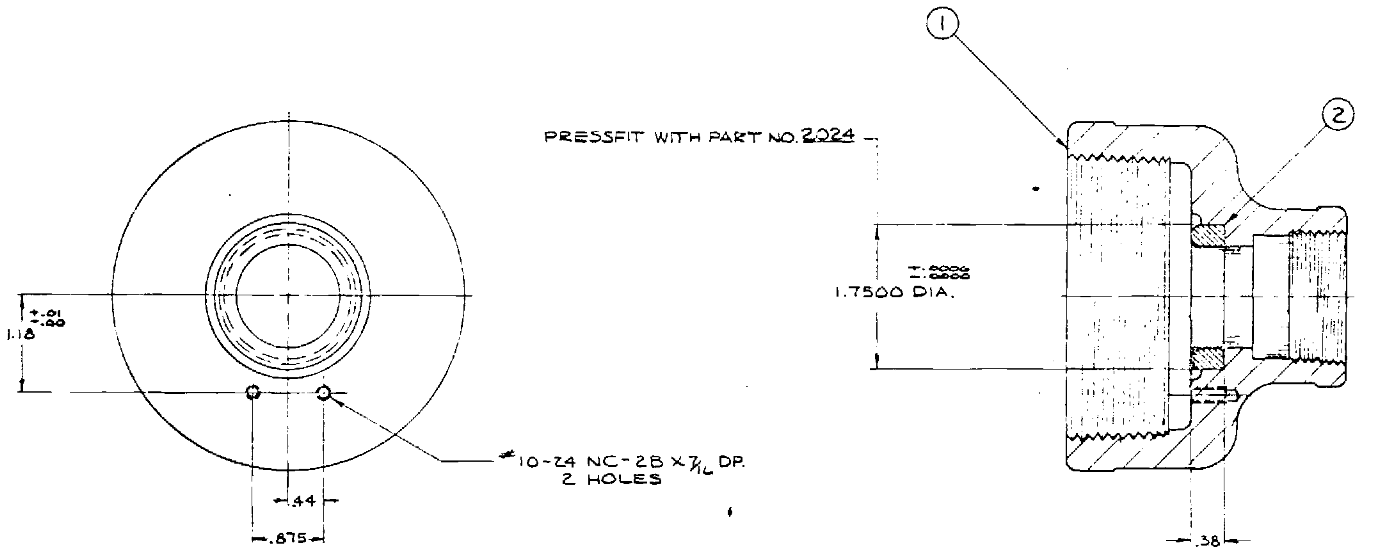
Battelle
Columbus Laboratories

TITLE
CHECK VALVE ASS'Y.

SIZE	CODE IDENT. NO.	DIV. NO.	DWG. NO.	REV.
B	79986	644	2015	

SCALE 1" = 1" ACCT. SHEET 1 OF 1

CAT. 904165
FORM D-7 12-73



REVISIONS				
ZONE	LTR.	DESCRIPTION	DATE	APPROVED

DWG. NO. 2016

FIND NO.	QTY.	PART NO. OR IDENTIFYING NO.	DWG SIZE	DESCRIPTION	SPECIFICATION	NOTE NO.
2	1	2024	A	BRASS VALVE SEAT		
1	1	2025	C	CYLINDER END CAP		

PARTS LIST

APPLICATION			
THIS ITEM IS USED ON SUBASSEMBLIES			
DRAWING NO.	PER ASSY	NO. OF ASSYS	TOTAL
2001	1	1	1
2002	1	1	1
TO MAKE FINAL ASSEMBLY			TOTAL REQ'D.

DO NOT SCALE DRAWING

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES. TOLERANCES ARE:

.XX = ±.01 .XXXX = –

.XXX = ±.005 ANGLES = –

MATERIAL AND TREATMENT

SIGNATURE	DIV	DATE
DRAWN BY	450	1-14-75
DRAFTING APPD.		
DESIGN APPD.		
APPD.		
APPD.		
PROJECT APPD.		
SPECIAL APPD.		

Battelle Columbus Laboratories
505 King Avenue
Columbus, Ohio 43201
Telephone (614) 299-3151

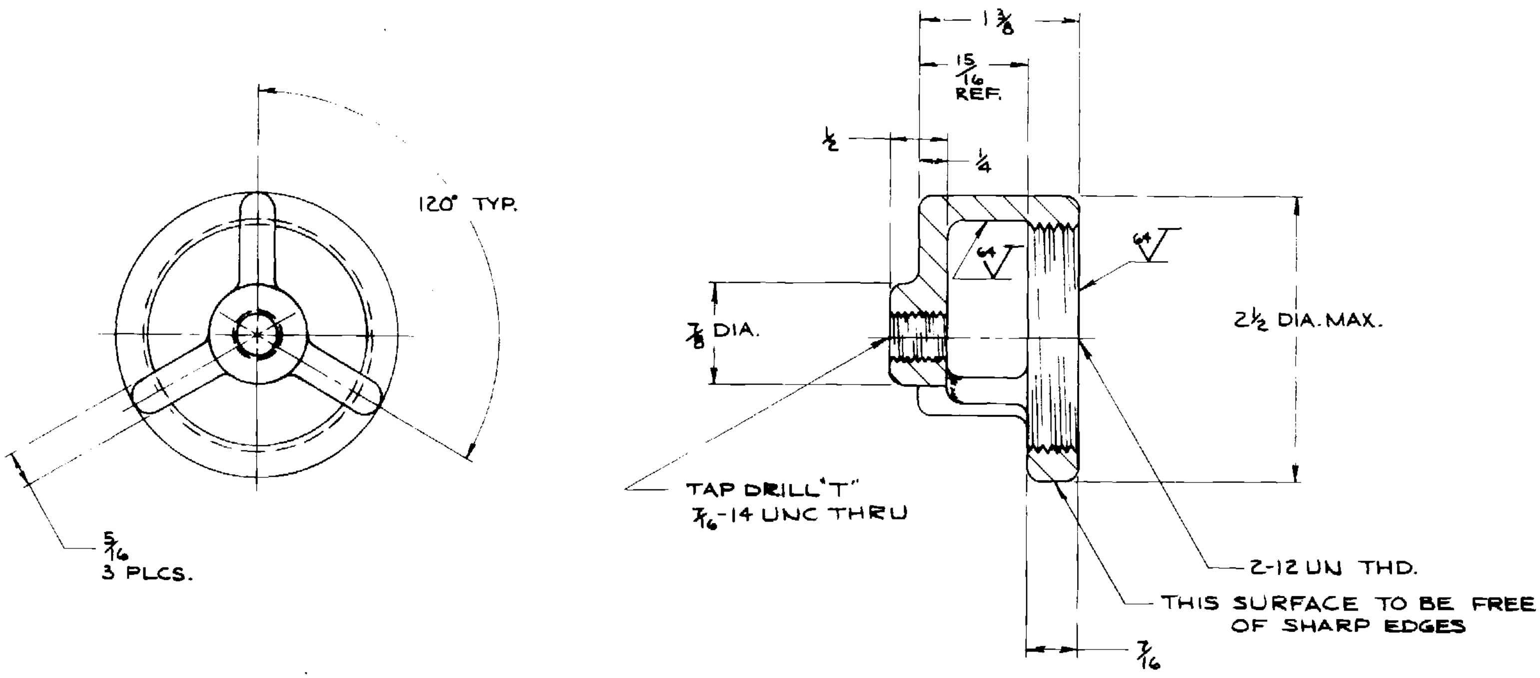
TITLE

LOWER VALVE HOUSING ASSY.

SIZE	CODE IDENT. NO.	DIV. NO.	DWG. NO.	REV.
C	79986	644	2016	

SCALE 1" = 1" ACCT. G1320-1 SHEET 1 OF 1

CAT. 300107 FORM B-6 12-73



NOTES:

1. ALL DRAFT ANGLES TO BE 1½° TO 4°
2. ALL FILLETS & RADII TO BE ⅛" R. UNLESS OTHERWISE SPECIFIED

REVISIONS

ZONE	LTR	DESCRIPTION	DATE	APPROVED

PARTS LIST

FIND NO.	QTY.	PART NO. OR IDENTIFYING NO.	DWG. SIZE	DESCRIPTION	SPECIFICATION	NOTE NO.

APPLICATION

THIS ITEM IS USED ON SUBASSEMBLIES

DRAWING NO.	PER ASSY		
2030	1	1	1
2009	1	1	1

TO MAKE FINAL ASSEMBLY

DO NOT SCALE DRAWING

TOLERANCES: .XX = .XXXX = .XXX = ANGLES = ±½°

MATERIAL & TREATMENT: CAST IRON

SIGNATURE	DIV.	DATE
DRAWN BY		1-5-75
DRAFTING APPD.		
DESIGN APPD.		
APPD.		
PROJECT APPD.		
SPECIAL APPD.		

Battelle Columbus Laboratories

TITLE: PLUNGER CAGE

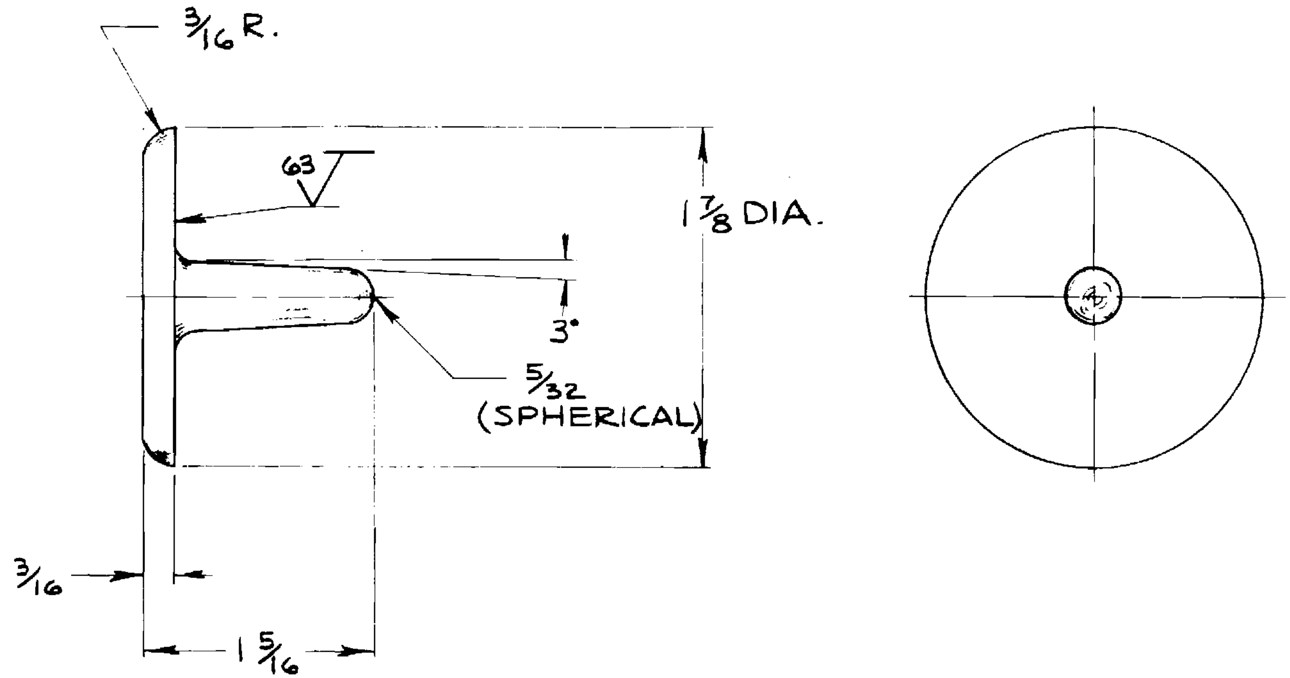
SIZE: B | CODE IDENT. NO. 79986 | 644 | DWG. NO. 2017

SCALE 1" = 1" | ACCT. G1320-1I | SHEET 1 OF 1

CAT. 284168 FORM E-7 12-73

NOTES:

1. ALL DRAFT ANGLES TO BE 1½° TO 4°
2. ALL FILLETS & RADII TO BE ⅛" R. UNLESS OTHERWISE SPECIFIED



REVISIONS			
LTR	DESCRIPTION	DATE	APPROVED

APPLICATION			
THIS ITEM IS USED ON SUBASSEMBLIES			
DRAWING NO.	PER ASSY	NO. OF ASSYS	TOTAL
2030	1	1	1
2009	1	1	1
TO MAKE FINAL ASSEMBLY			TOTAL REQ'D.

DO NOT SCALE DRAWING

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES. TOLERANCES ARE: ± 1/32

.XX = – .XXXX = –

.XXX = – ANGLES = ± ½°

MATERIAL & TREATMENT

CAST IRON

SIGNATURE	DIV.	DATE
DRAWN BY [illegible]	659	1-7-75
DRAFTING APPD.		
DESIGN APPD.		
APPD.		
PROJECT APPD.		
SPECIAL APPD.		

BATTELLE MEMORIAL INSTITUTE
COLUMBUS LABORATORIES
505 KING AVE., COLUMBUS, OHIO 43201

TITLE

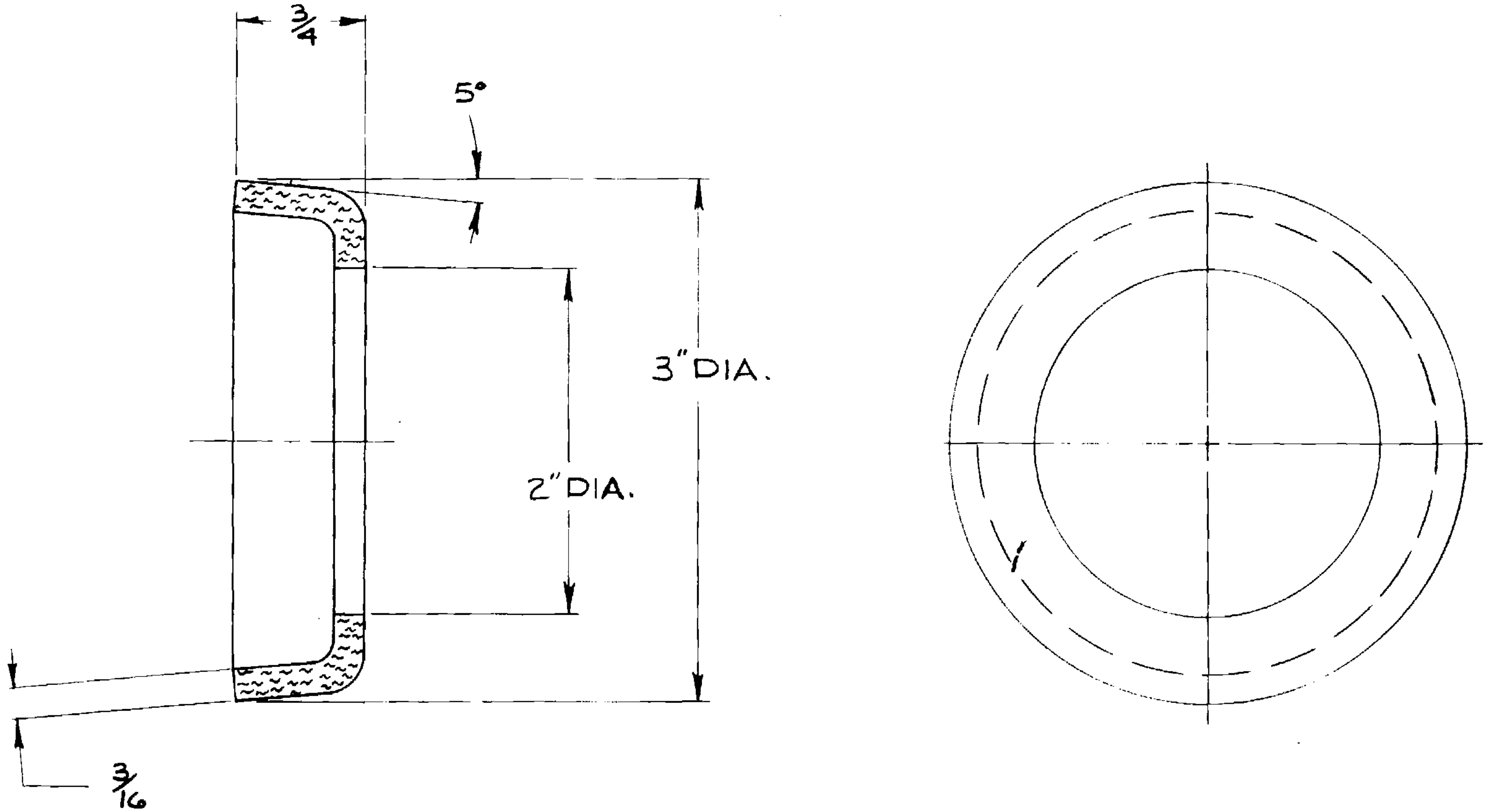
PLUNGER POPPET

SIZE	CODE IDENT. NO.	DIV. NO.	DWG. NO.	REV.
A	79986	644	2018	

SCALE 1"=1" ACCT. G1320-1 SHEET 1 OF 1

CAT. 294163 FORM D-5 5-70

REVISIONS			
LTR	DESCRIPTION	DATE	APPROVED



APPLICATION			
THIS ITEM IS USED ON SUBASSEMBLIES			
DRAWING NO.	PER ASSY	NO. OF ASSYS	TOTAL
2009	1	1	1
2030	1	1	1
TO MAKE FINAL ASSEMBLY			TOTAL REQ'D.

DO NOT SCALE DRAWING

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES. TOLERANCES ARE: ± 1/32
.XX = – .XXXX = –
.XXX = – ANGLES = ± 1°

MATERIAL & TREATMENT
LEATHER

SIGNATURE	DIV.	DATE
DRAWN BY	659	1-7-75
DRAFTING APPD.		
DESIGN APPD.		
APPD.		
PROJECT APPD.		
SPECIAL APPD.		

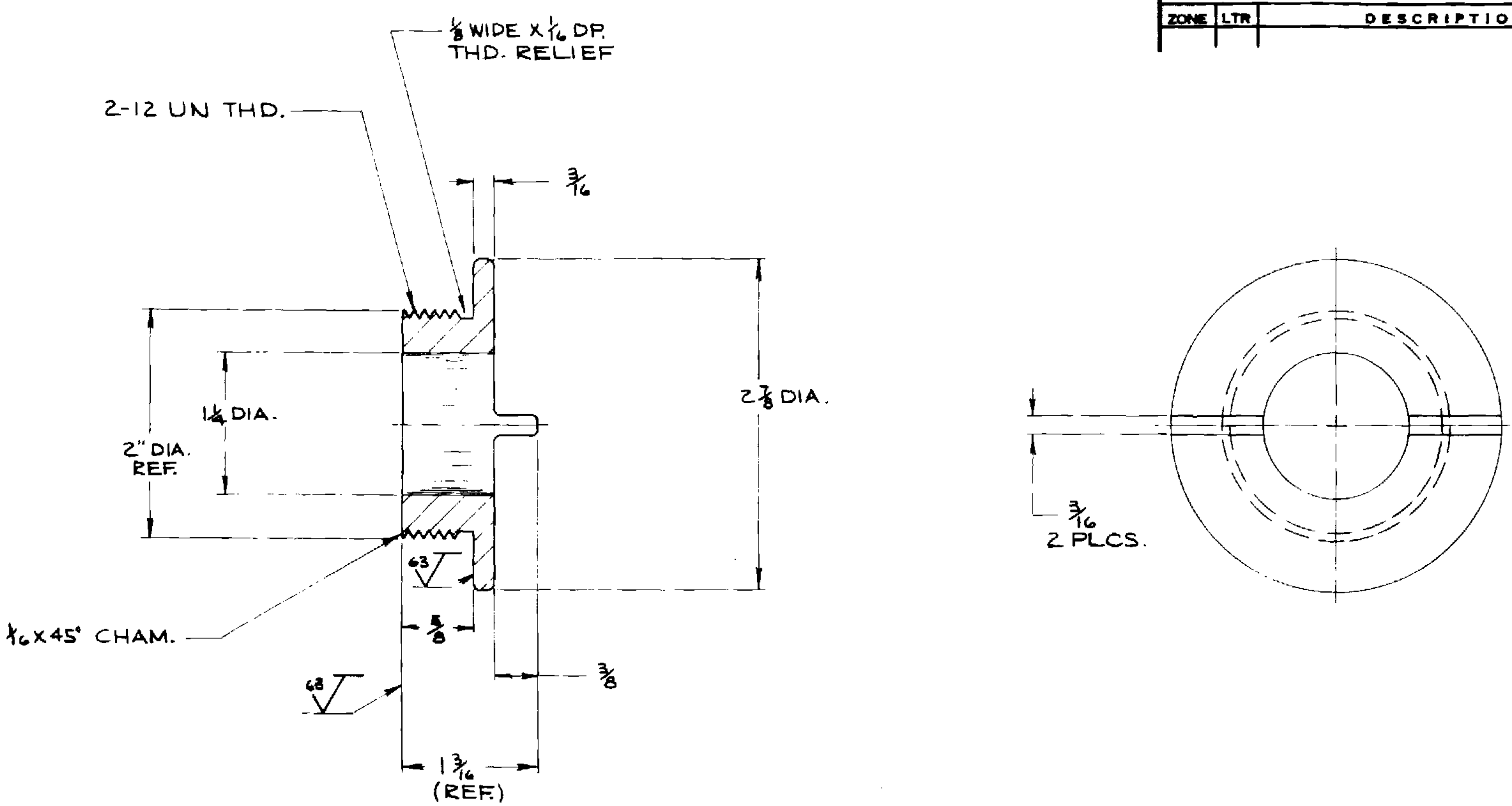
BATTELLE MEMORIAL INSTITUTE
COLUMBUS LABORATORIES
505 KING AVE., COLUMBUS, OHIO 43201

TITLE
THREE INCH CUP

SIZE	CODE IDENT. NO.	DIV. NO.	DWG. NO.	REV.
A	79986	644	2019	

SCALE 1" = 1" ACCT. G1320-1 SHEET 1 OF 1

CAT. 294163 FORM D-5 5-70+



NOTES:

1. ALL DRAFT ANGLES TO BE 1½° TO 4°
2. ALL FILLETS & RADII TO BE 1/16" R. UNLESS OTHERWISE SPECIFIED

REVISIONS				
ZONE	LTR	DESCRIPTION	DATE	APPROVED

FIND NO.	QTY.	PART NO. OR IDENTIFYING NO.	DWG. SIZE	DESCRIPTION	SPECIFICATION	NOTE NO.

PARTS LIST

APPLICATION		
THIS ITEM IS USED ON SUBASSEMBLIES		
DRAWING NO.	PER ASSY	
2009	1	1
TO MAKE FINAL ASSEMBLY		

DO NOT SCALE DRAWING

TOLERANCES ANG: ± 1/32
.XX = – .XXXX = –
.XXX = – ANGLES = ± ½°

MATERIAL & TREATMENT
CAST IRON

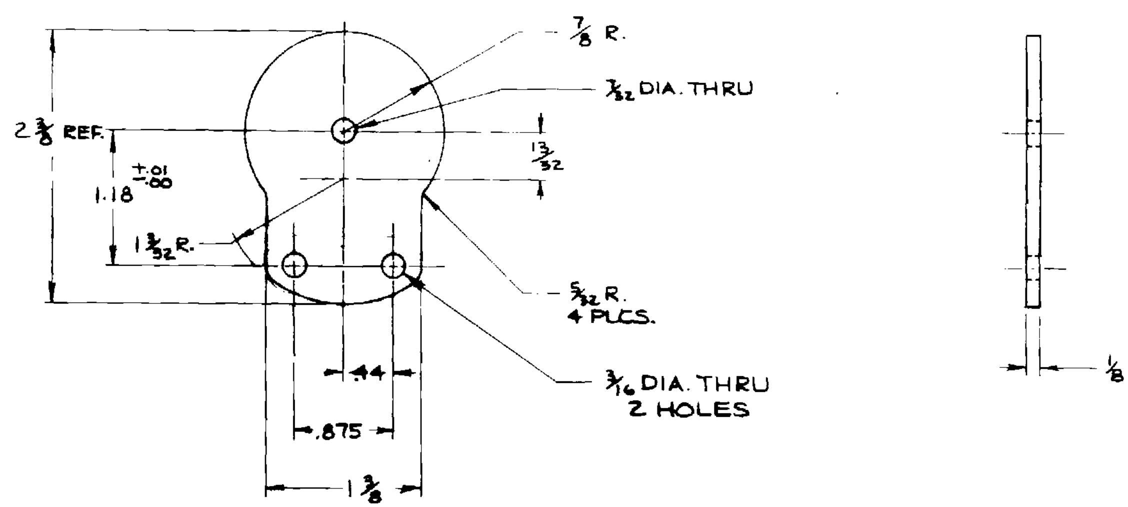
SIGNATURE	DIV.	DATE
DRAWN BY	644	1-8-75
DRAFTING APPD.		
DESIGN APPD.		
APPD.		
PROJECT APPD.		
SPECIAL APPD.		

Battelle Columbus Laboratories

TITLE: PLUNGER FOLLOWER SINGLE CUP

SIZE	CODE IDENT. NO.	DIV. NO.	DWG. NO.	REV.
B	79986	644	2020	

SCALE 1" = 1" ACCT. G1320-1 SHEET 1 OF 1



REVISIONS				
ZONE	LTR	DESCRIPTION	DATE	APPROVED

FIND NO.	QTY.	PART NO. OR IDENTIFYING NO.	DWG. SIZE	DESCRIPTION	SPECIFICATION	NOTE NO.

PARTS LIST

APPLICATION

THIS ITEM IS USED ON

DRAWING NO. 2015

TO MAKE FINAL ASSEMBLY

DO NOT SCALE DRAWING

TOLERANCES ± 1/32

.XX ± .01 .XXXX ± –

.XXX ± .005 ANGLES ± –

MATERIAL & TREATMENT

LEATHER

SIGNATURE	DIV.	DATE
DRAWN BY		6-8-78
DRAFTING APPD.		
DESIGN APPD.		
APPD.		
PROJECT APPD.		
SPECIAL APPD.		

Battelle
Columbus Laboratories

505 King Avenue
Columbus, Ohio 43201
Telephone (614) 299-3151

TITLE

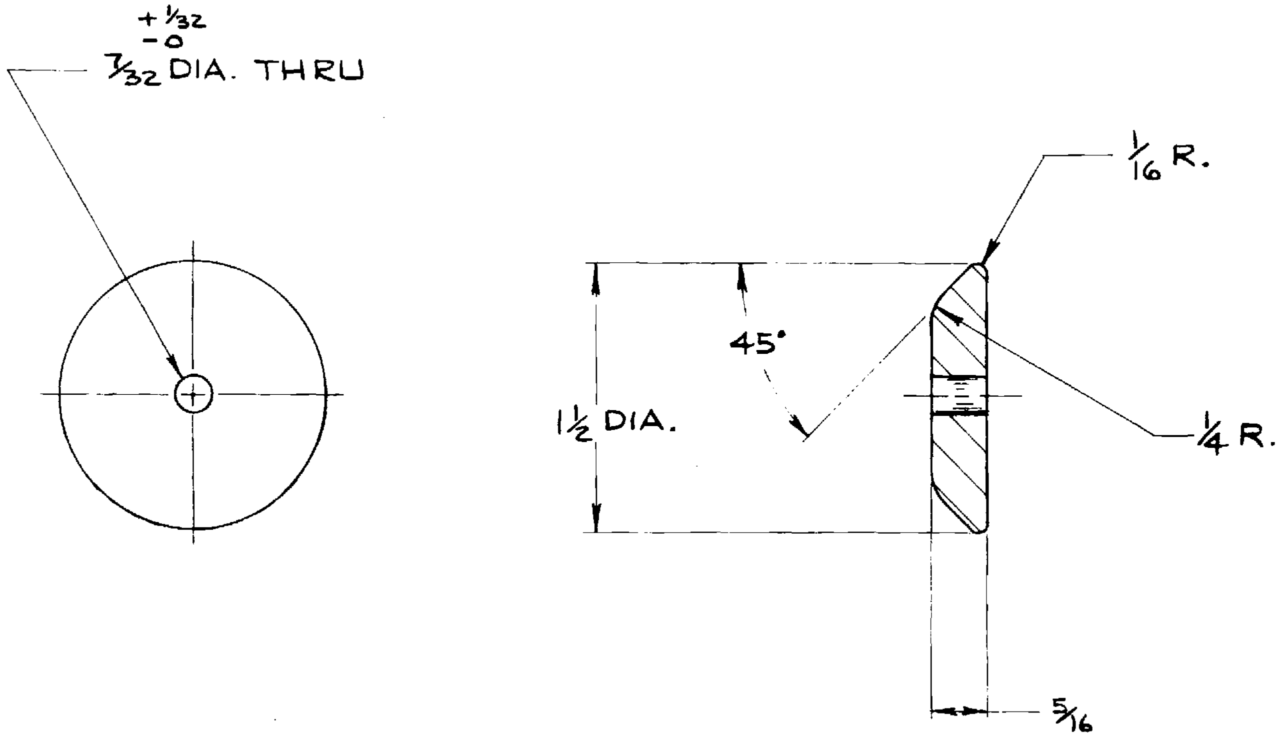
VALVE FLAPPER

SIZE	CODE IDENT. NO.	DIV. NO.	DWG. NO.	REV.
B	79986	644	2021	

SCALE 1" = 1" ACCT. G1320-1 SHEET 1 OF 1

CAT. 604168 FORM E-7 TS-78

REVISIONS			
LTR	DESCRIPTION	DATE	APPROVED



APPLICATION			
THIS ITEM IS USED ON SUBASSEMBLIES			
DRAWING NO.	PER ASSY	NO. OF ASSYS	TOTAL
2015	1	1	1
TO MAKE FINAL ASSEMBLY			TOTAL REQ'D.

DO NOT SCALE DRAWING

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES. TOLERANCES ARE: 1/32

.XX = – .XXXX = –

.XXX = – ANGLES = ± 1/2°

MATERIAL & TREATMENT

CAST IRON

SIGNATURE	DIV.	DATE
DRAWN BY gmw	659	1-8-75
DRAFTING APPD.		
DESIGN APPD.		
APPD.		
PROJECT APPD.		
SPECIAL APPD.		

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COLUMBUS LABORATORIES
505 KING AVE., COLUMBUS, OHIO 43201

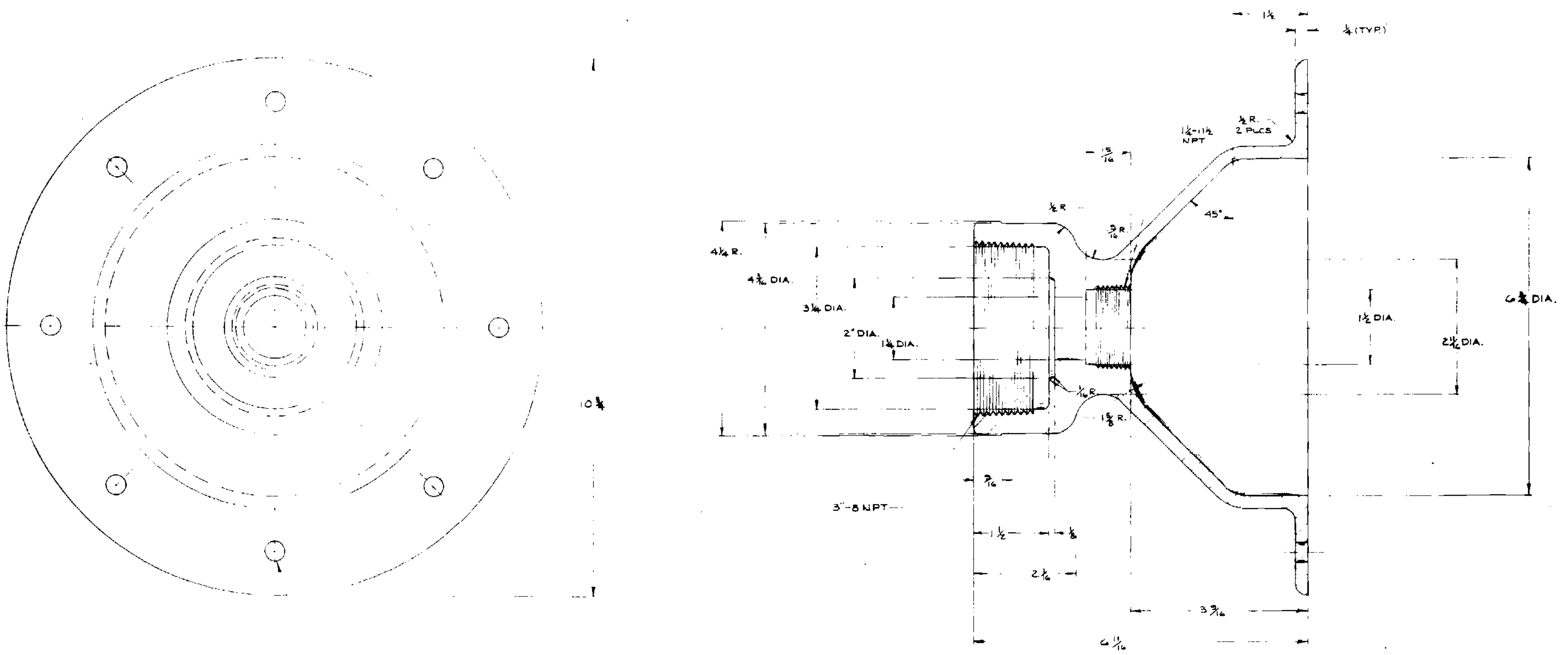
TITLE

CHECK VALVE WEIGHT

SIZE	CODE IDENT. NO.	DIV. NO.	DWG. NO.	REV.
A	79986	644	2022	

SCALE 1" = 1" ACCT G1320-1 SHEET 1 OF 1

CAT. 294163 FORM D-5 5-70



13/32 DIA. THRU
8 HOLES EQUALLY SPACED
ON 9" DIA. B.C.

NOTES:

1. ALL DRAFT ANGLES TO BE 1½° TO 4°
2. ALL FILLETS & RADII TO BE ⅛" R. UNLESS OTHERWISE SPECIFIED
3. MOUNTING HOLES SHOWN HERE ARE FOR ⅜" BOLTS, BUT FLANGE IS WIDE ENOUGH FOR ½" BOLTS & WASHERS

REVISIONS

ZONE	LTR.	DESCRIPTION	DATE	APPROVED

FIND NO.	QTY.	PART NO. OR IDENTIFYING NO.	DWG. SIZE	DESCRIPTION

PARTS LIST

APPLICATION — THIS ITEM IS USED ON ASSEMBLIES

DRAWING NO.	PER ASSY	NO. OF ASSYS	TOTAL
2001	1	1	1
2002	1	1	1

TO MAKE FINAL ASSEMBLY — TOTAL REQ'D.

DO NOT SCALE DRAWING

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES. TOLERANCES ARE: ± 1/32

MATERIAL AND TREATMENT: CAST IRON

SIGNATURE / DIV. / DATE: 1-14-75

Battelle Columbus Laboratories

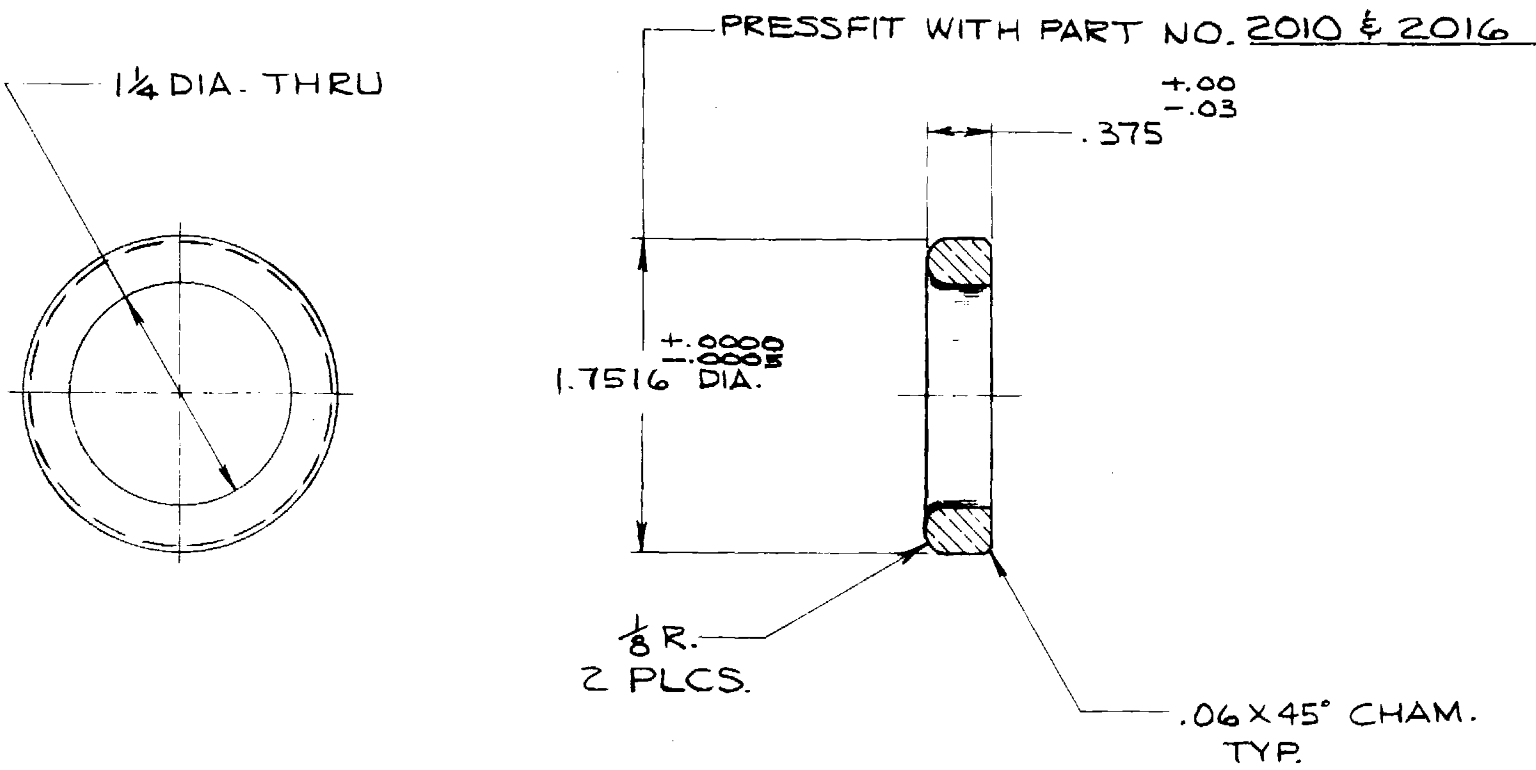
TITLE: PUMP STAND

SIZE: D — CODE IDENT. NO. 79986 — DIV. NO. 644 — DWG. NO. 2023

SCALE 1" = 1" — ACCT. G 13209 — SHEET 1 OF 1

2023

REVISIONS			
LTR	DESCRIPTION	DATE	APPROVED



APPLICATION			
THIS ITEM IS USED ON SUBASSEMBLIES			
DRAWING NO.	PER ASSY	NO. OF ASSYS	TOTAL
2010	1	1	1
2016	1	1	1
TO MAKE FINAL ASSEMBLY			TOTAL REQ'D.

DO NOT SCALE DRAWING

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES. TOLERANCES ARE: ± 1/32

.XX = ±.01 .XXXX = –

.XXX = – ANGLES = ± ½°

MATERIAL & TREATMENT

BRASS

SIGNATURE	DIV.	DATE
DRAWN BY [illegible]	659	1-7-75
DRAFTING APPD.		
DESIGN APPD.		
APPD.		
PROJECT APPD.		
SPECIAL APPD.		

BATTELLE MEMORIAL INSTITUTE
COLUMBUS LABORATORIES
505 KING AVE., COLUMBUS, OHIO 43201

TITLE

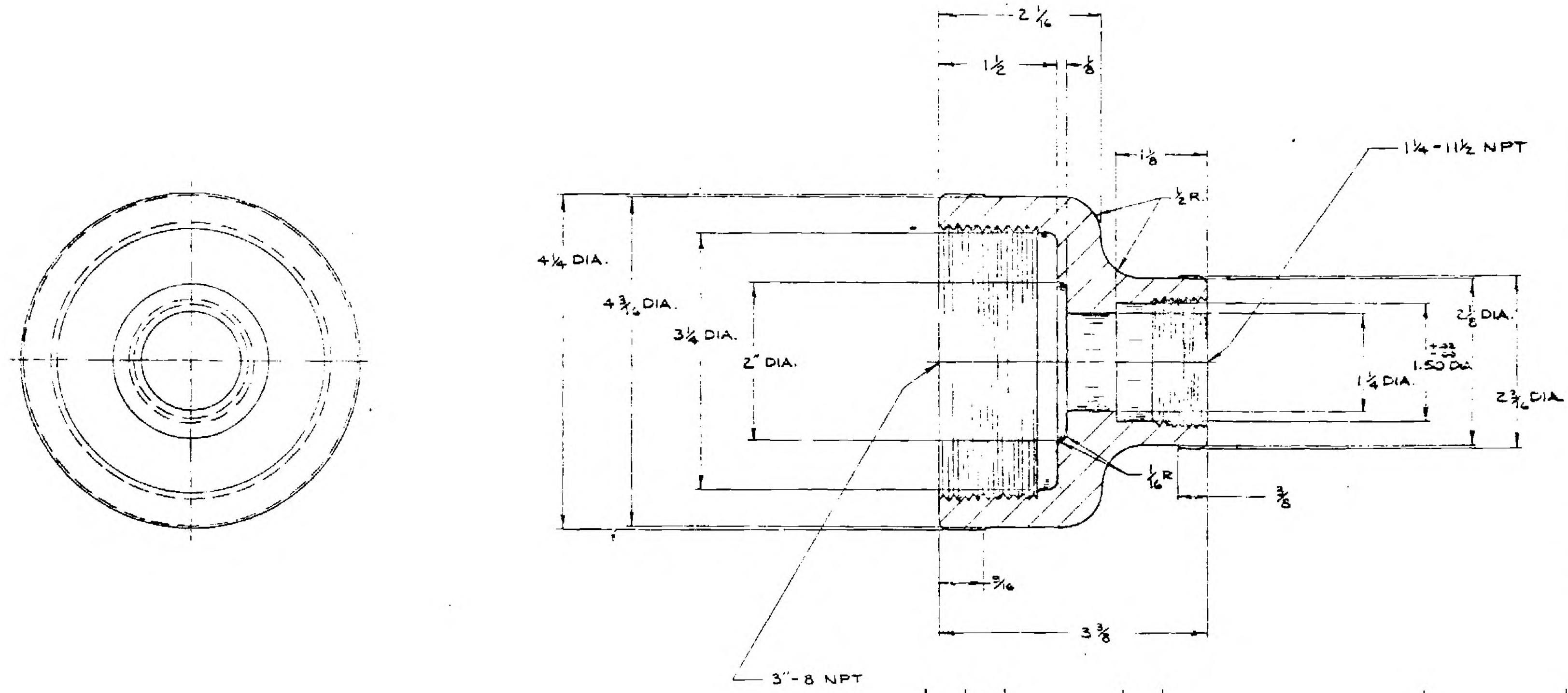
BRASS
VALVE SEAT

SIZE	CODE IDENT. NO.	DIV. NO.	DWG. NO.	REV.
A	79986	644	2024	

SCALE 1" = 1" ACCT. G 1320-1 SHEET 1 OF 1

CAT. 294163 FORM D-5 5-70

ZONE	LTR.	REVISIONS DESCRIPTION	DATE	APPROVED



NOTES:

1. ALL DRAFT ANGLES TO BE 1 1/2° TO 4°
2. ALL FILLETS & RADII TO BE 1/8" R. UNLESS OTHERWISE SPECIFIED

FIND NO.	QTY.	PART NO. OR IDENTIFYING NO.	DWG. SIZE	DESCRIPTION	SPECIFICATION	NOTE NO.

PARTS LIST

APPLICATION

THIS ITEM IS USED ON SUBASSEMBLIES

DRAWING NO.	PER ASSY	NO. OF ASSYS	TOTAL
2016	1	1	1
2032	1	1	1
2001"C"	1	1	1

TO MAKE FINAL ASSEMBLY — TOTAL REQ'D

DO NOT SCALE DRAWING

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES. TOLERANCES ARE: ± 1/32

.XX = — .XXXX = —

.XXX = — ANGLES = ± 1/2°

MATERIAL AND TREATMENT: CAST IRON

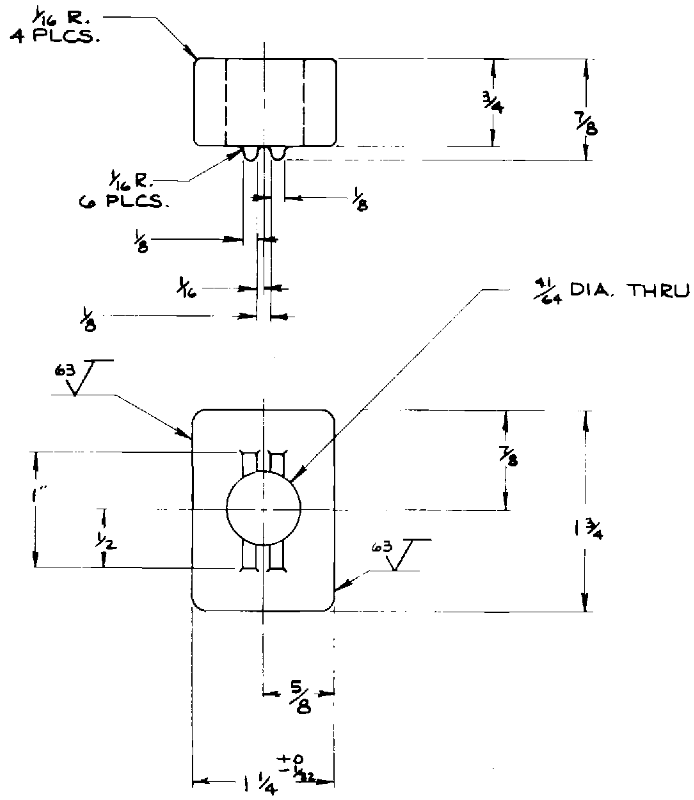
SIGNATURE	DIV.	DATE
CHECKED BY	GEP	1-10-73
DRAFTING APPD.		
DESIGN APPD.		
APPD.		
APPD.		
PROJECT APPD.		
SPECIAL APPD.		

Battelle Columbus Laboratories
505 King Avenue Columbus, Ohio 43201 Telephone (614) 299-3151

TITLE: CYLINDER END CAP

SIZE	CODE IDENT. NO.	DIV. NO.	DWG. NO.	REV.
C	79986	644	2025	

SCALE 1"=1" ACCT G1320-1 SHEET 1 OF 1



NOTES:

1. ALL DRAFT ANGLES TO BE 1½° TO 4°
2. ALL FILLETS & RADII TO BE 1/8" R. UNLESS OTHERWISE SPECIFIED

REVISIONS				
ZONE	LTR	DESCRIPTION	DATE	APPROVED

FIND NO.	QTY.	PART NO. OR IDENTIFYING NO.	DWG. SIZE	DESCRIPTION	SPECIFICATION	NOTE NO.

PARTS LIST

APPLICATION			
THIS ITEM IS USED ON SUBASSEMBLIES			
DRAWING NO.	PER ASSY	NO. OF ASSYS	TOTAL
2002	2	1	2
TO MAKE FINAL ASSEMBLY			TOTAL REQ'D.

DO NOT SCALE DRAWING

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES. TOLERANCES ARE: ± 1/64

.XX = – .XXXX = –
.XXX = – ANGLES = –

MATERIAL & TREATMENT: CAST IRON

SIGNATURE	DIV.	DATE
DRAWN BY	653	1-8-79
DRAFTING APPD.		
DESIGN APPD.		
APPD.		
PROJECT APPD.		
SPECIAL APPD.		

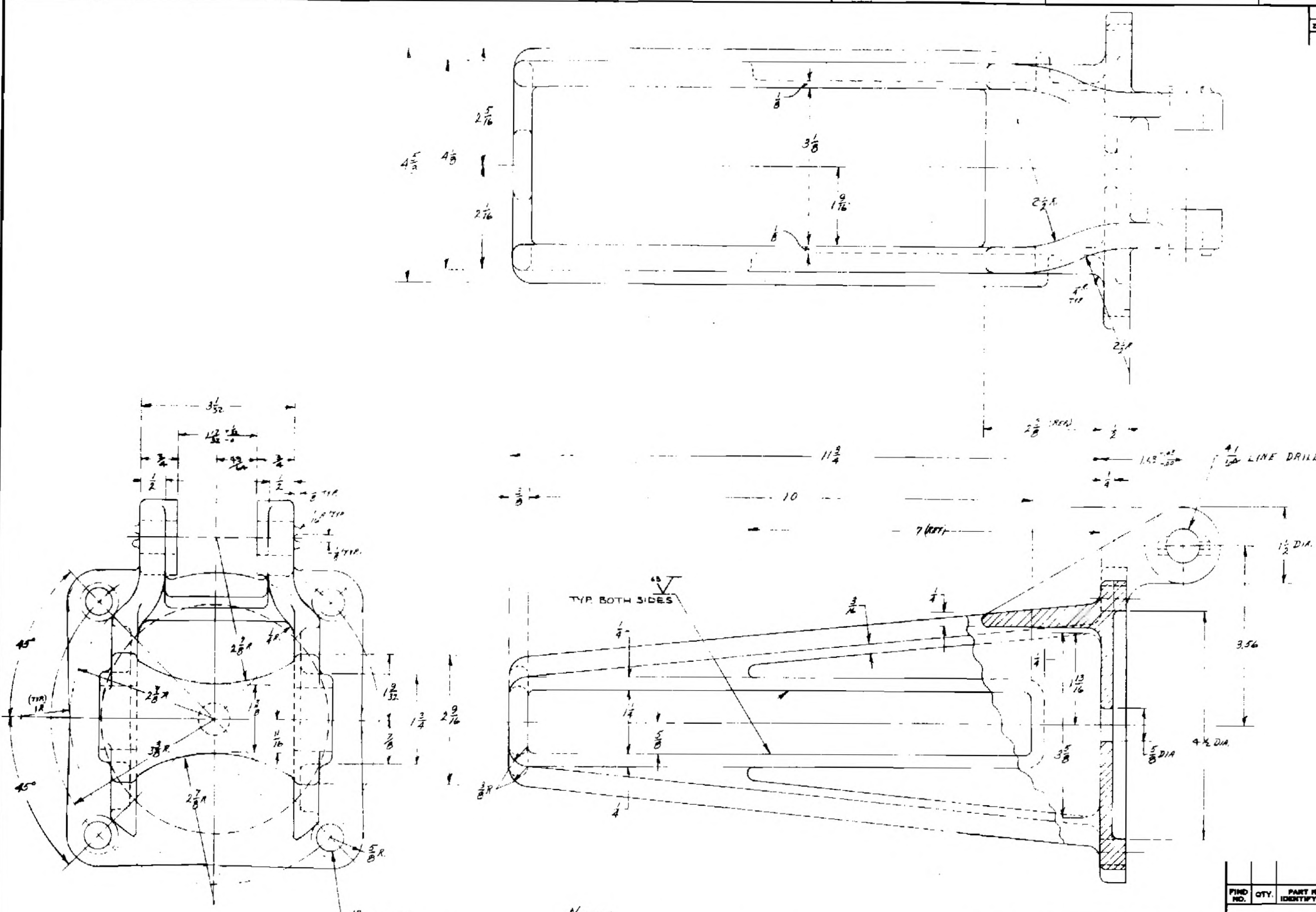
Battelle
Columbus Laboratories
505 King Avenue
Columbus, Ohio 43201
Telephone (614) 299-3151

TITLE: SLIDING BLOCK

SIZE	CODE IDENT. NO.	DIV. NO.	DWG. NO.	REV.
B	79986	644	2026	

SCALE 1"=1" ACCT. G1320-1 SHEET 1 OF 1

CAT. 894166 FORM B-7 12-73



NOTE.
1. ALL DRAFT ANGLES TO BE 1 1/2° TO 4°
2. ALL RADII & FILLETS TO BE 1/8 UNLESS OTHERWISE SPECIFIED.

FIND NO.	QTY.	PART NO. OR IDENTIFYING NO.	DWG. SIZE	DESCRIPTION	SPECIFICATION	NOTE NO.

PARTS LIST

APPLICATION			
THIS ITEM IS USED ON SUBASSEMBLIES			
DRAWING NO.	PER ASSY	NO. OF ASSYS	TOTAL
2002	1	1	1
TO MAKE FINAL ASSEMBLY			TOTAL REQ'D.

DO NOT SCALE DRAWING

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES. TOLERANCES ARE: ±1/64
.XX = ±.01 .XXXX = —
.XXX = — ANGLES = ± 1/2°

MATERIAL AND TREATMENT: CAST IRON

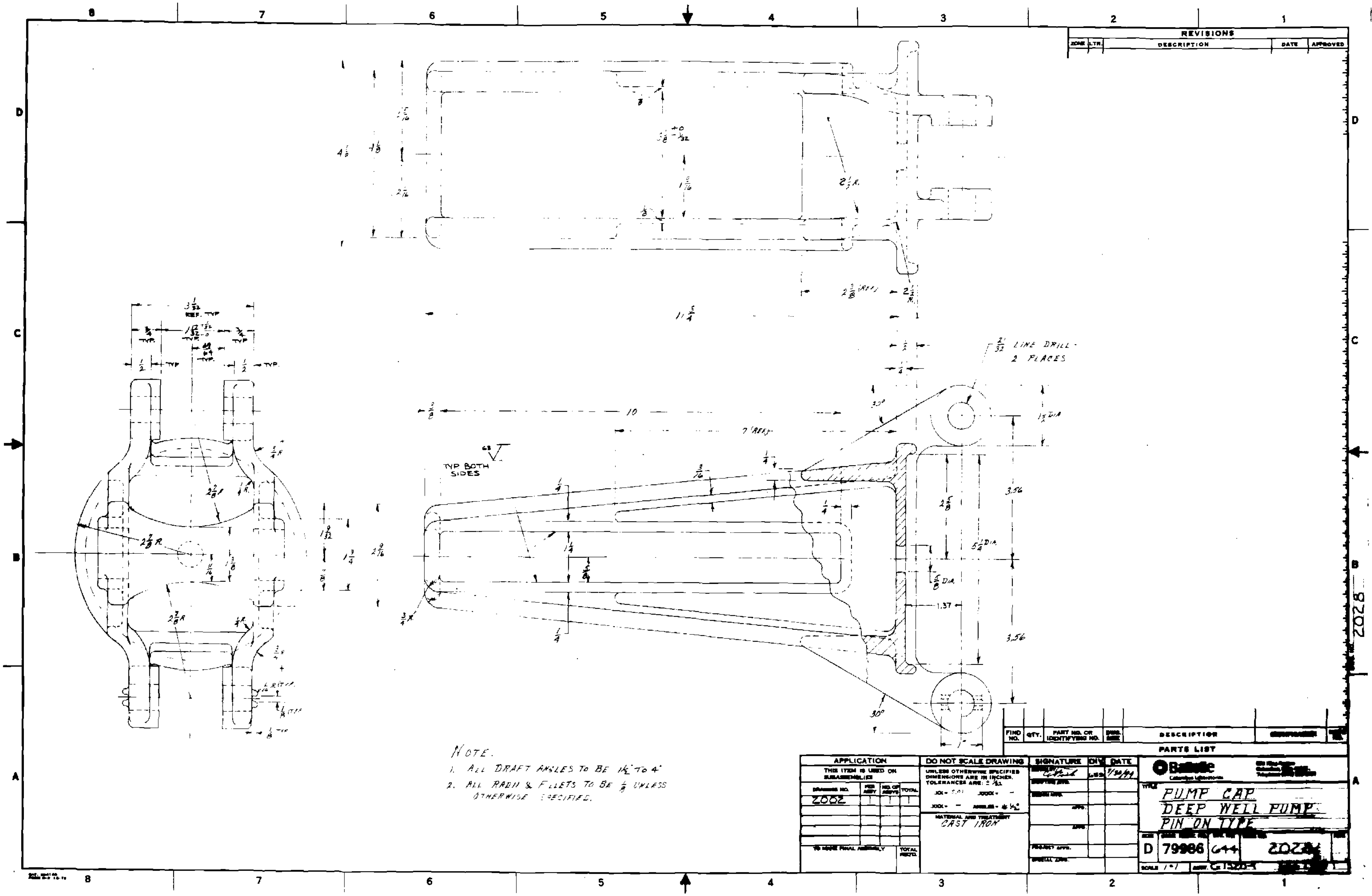
SIGNATURE	DIV.	DATE
DRAWN BY		
DRAFTING APPR.		
DESIGN APPR.		
APPR.		
APPR.		
PROJECT APPR.		
SPECIAL APPR.		

Battelle
Columbus Laboratories

TITLE: PUMP CAP
DEEP WELL PUMP
BOLT ON TYPE

SIZE	CODE IDENT NO.	DIV. NO.	DWG. NO.	REV.
D	79986	644	2027	

SCALE 1/1 ACCT. G1520-1 SHEET 1 OF 1



NOTE.

1. ALL DRAFT ANGLES TO BE $1\frac{1}{2}°$ TO 4°
2. ALL RADII & FILLETS TO BE $\frac{1}{8}$ UNLESS OTHERWISE SPECIFIED.

FIND NO.	QTY.	PART NO. OR IDENTIFYING NO.	DWG. SIZE	DESCRIPTION

PARTS LIST

APPLICATION			
THIS ITEM IS USED ON SUBASSEMBLIES			
DRAWING NO.	PER ASSY	NO. OF ASSYS	TOTAL
2002			
TO MAKE FINAL ASSEMBLY			TOTAL REQ'D.

DO NOT SCALE DRAWING

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES. TOLERANCES ARE: ± 1/32

MATERIAL AND TREATMENT: CAST IRON

SIGNATURE	DIV	DATE

Battelle Columbus Laboratories

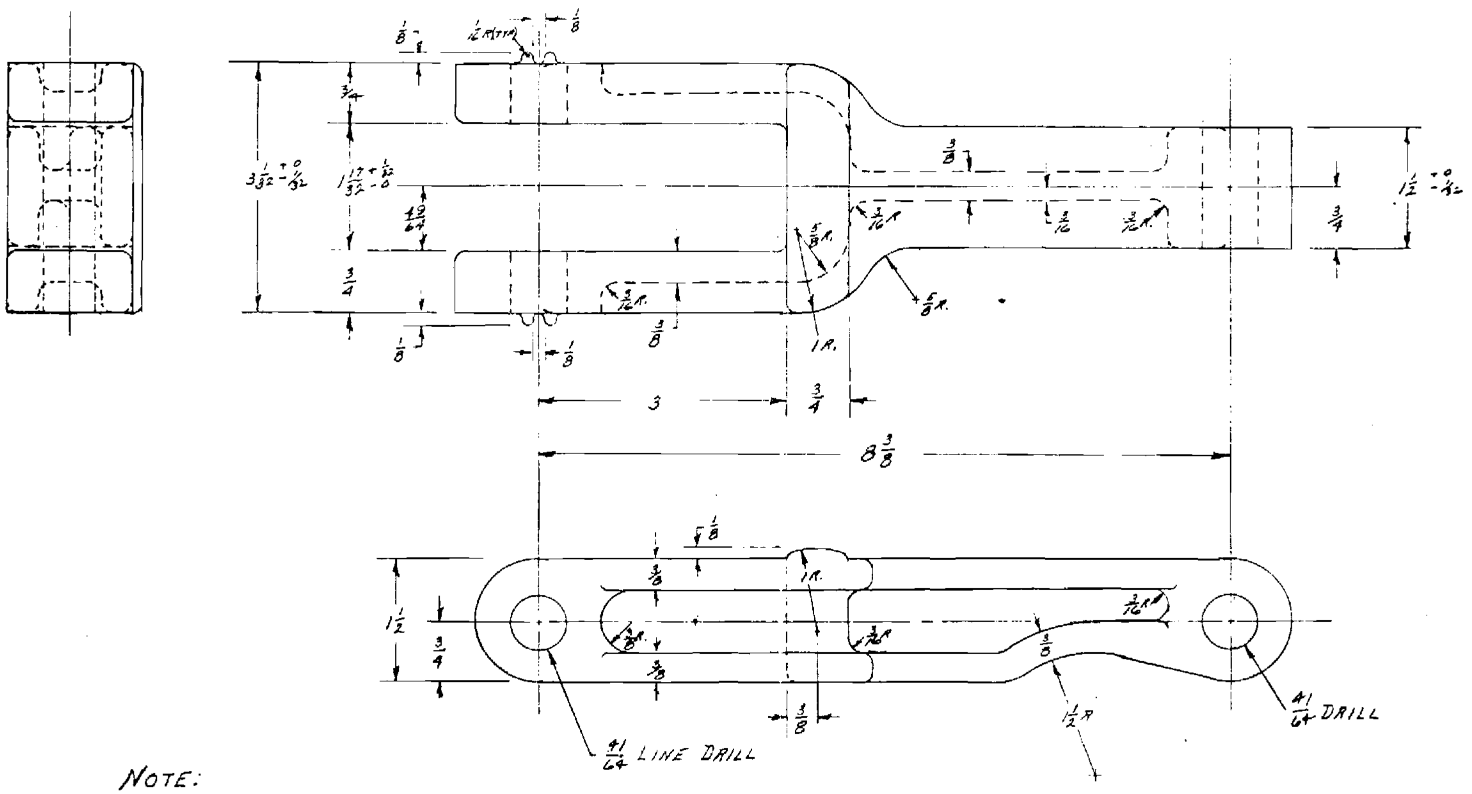
TITLE: PUMP CAP DEEP WELL PUMP PIN ON TYPE

SIZE D | 79986 | 644 | 2028

SCALE 1"=1"

REVISIONS

ZONE	LTR.	DESCRIPTION	DATE	APPROVED



NOTE:

1. ALL DRAFT ANGLES TO BE $1\frac{1}{2}°$ TO 4°
2. ALL RADII & FILLETS $\frac{1}{8}''$ UNLESS OTHERWISE SPECIFIED.

FIND NO.	QTY.	PART NO. OR IDENTIFYING NO.	DWG. SIZE	DESCRIPTION	SPECIFICATION	NOTE NO.

PARTS LIST

APPLICATION			
THIS ITEM IS USED ON ASSEMBLIES			
DRAWING NO.	PER ASSY	NO. OF ASSYS	TOTAL
2002	1	1	1
TO MAKE FINAL ASSEMBLY			TOTAL REQ'D.

DO NOT SCALE DRAWING

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES. TOLERANCES ARE: ± 1/32

.XX = — .XXXX = —

.XXX = — ANGLES = —

MATERIAL AND TREATMENT: CAST IRON

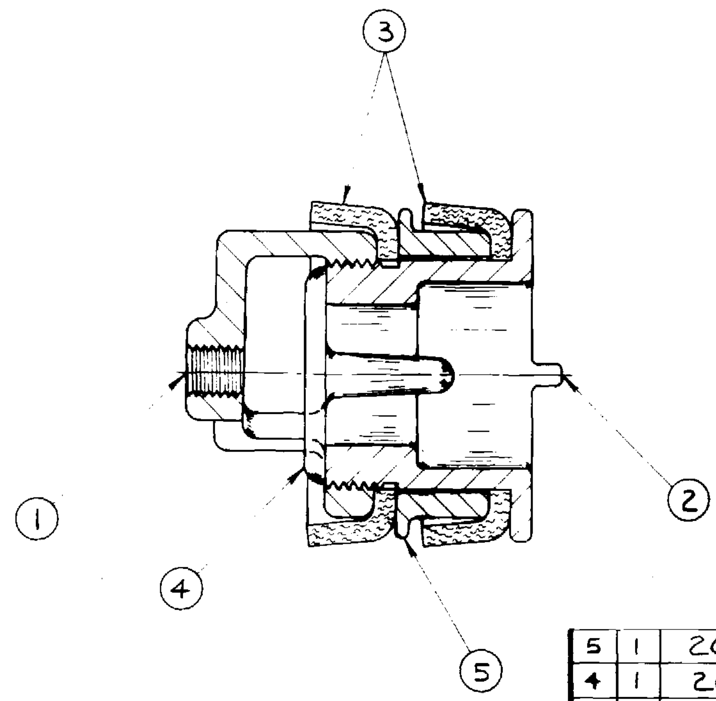
SIGNATURE	DIV.	DATE
DRAWN BY C. Fink	666	5/5/74
DRAFTING APPD.		
DESIGN APPD.		
APPD.		
APPD.		
PROJECT APPD.		
SPECIAL APPD.		

505 King Avenue
Columbus, Ohio 43201
Telephone (614) 299-3151

TITLE: HANDLE FULCRUM - DEEP WELL PUMP

SIZE	CODE IDENT. NO.	DEV. NO.	DWG. NO.	REV.
C	79986	644	2029	

SCALE 1=1 ACCT. G-2942-0001 SHEET 1 OF 1



FIND NO.	QTY.	PART NO. OR IDENTIFYING NO.	DWG. SIZE	DESCRIPTION	SPECIFICATION	NOTE NO.
5	1	2032	A	PLUNGER SPACER		
4	1	2018	A	PLUNGER POPPET		
3	2	2019	A	THREE INCH CUP		
2	1	2031	B	PLUNGER FOLLOWER		
1	1	2017	B	PLUNGER CAGE		

PARTS LIST

NOTE:

1. DOUBLE CUP PLUNGER TO BE USED WHEN WATER LEVEL IS MORE THAN 50 FT. BELOW SURFACE

ZONE	LTR	REVISIONS DESCRIPTION	DATE	APPROVED

APPLICATION

THIS ITEM IS USED ON ASSEMBLIES

DRAWING NO.	PER ASSY	[illegible]	TOTAL
2002	1	1	1

TO MAKE FINAL ASSEMBLY — TOTAL REQ'D.

DO NOT SCALE DRAWING

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES. TOLERANCES ARE:

.XX = .XXXX =
.XXX= ANGLES=

MATERIAL & TREATMENT

SIGNATURE	DIV.	DATE
DRAWN BY [illegible]		[illegible]-10-7[illegible]
DRAFTING APPD.		
DESIGN APPD.		
APPD.		
PROJECT APPD.		
SPECIAL APPD.		

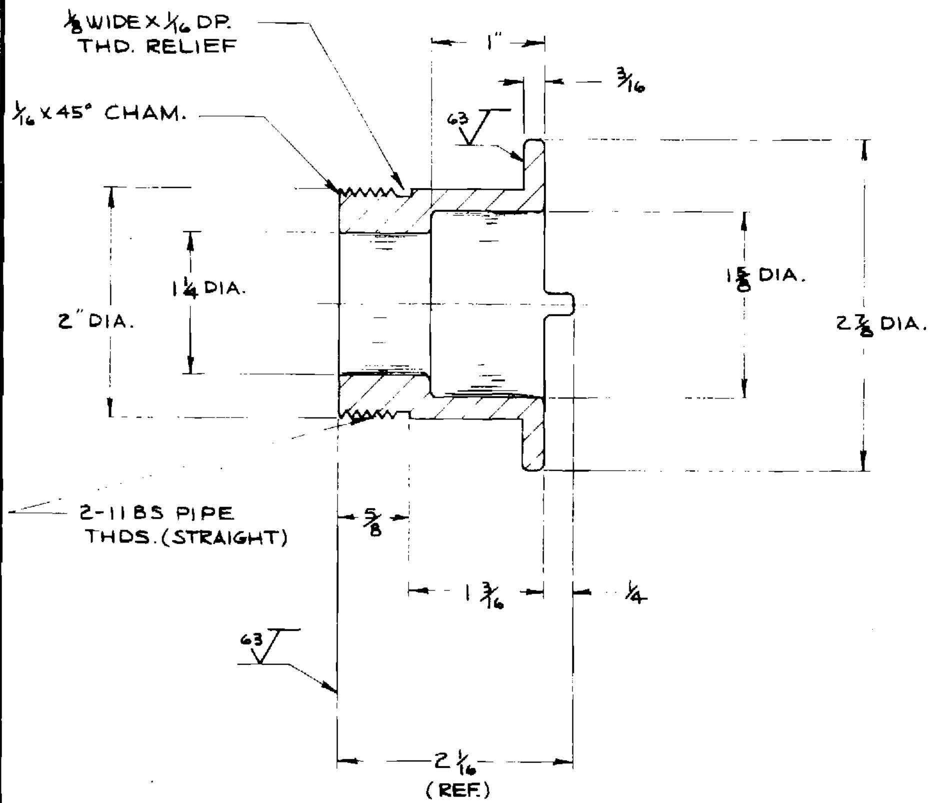
Battelle Columbus Laboratories
505 King Avenue
Columbus, Ohio 43201
Telephone (614) 299-3151

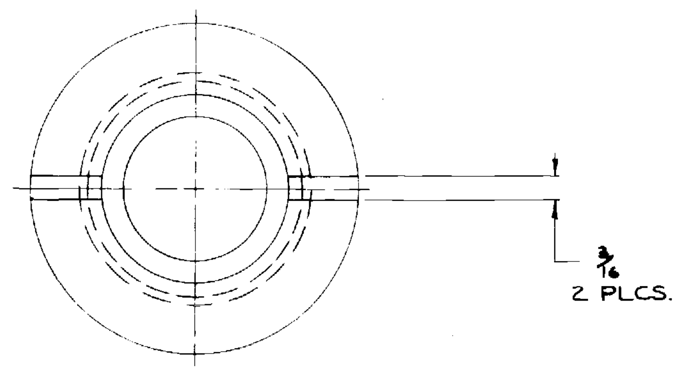
TITLE THREE INCH PLUNGER ASSY, DOUBLE CUP

SIZE	CODE IDENT. NO.	DIV. NO.	DWG. NO.	REV.
B	79986	644	2030	

SCALE " = " ACCT. SHEET 1 OF 1

CAT. 294108 FORM D-7 12-73





NOTES:

1. ALL DRAFT ANGLES TO BE 1½° TO 4°
2. ALL FILLETS & RADII TO BE 1/16" R. UNLESS OTHERWISE SPECIFIED

FIND NO.	QTY.	PART NO. OR IDENTIFYING NO.	DWG. SIZE	DESCRIPTION	SPECIFICATION	NOTE NO.

PARTS LIST

APPLICATION — THIS ITEM IS USED ON SUBASSEMBLIES

DRAWING NO.	PER ASSY		TOTAL
2030	1	1	1

TO MAKE FINAL ASSEMBLY — TOTAL REQ'D.

DO NOT SCALE DRAWING

UNLESS OTHERWISE SPECIFIED TOLERANCES ARE: ± 1/32
.XX = – .XXXX = –
.XXX = – ANGLES = ± 1/2°

MATERIAL & TREATMENT: CAST IRON

SIGNATURE	DIV.	DATE
DRAWN BY		
DRAFTING APPD.		
DESIGN APPD.		
APPD.		
PROJECT APPD.		
SPECIAL APPD.		

Battelle Columbus Laboratories

TITLE: PLUNGER FOLLOWER

SIZE: B | CODE IDENT. NO.: 79986 | DIV.: 644 | DWG. NO.: 2031

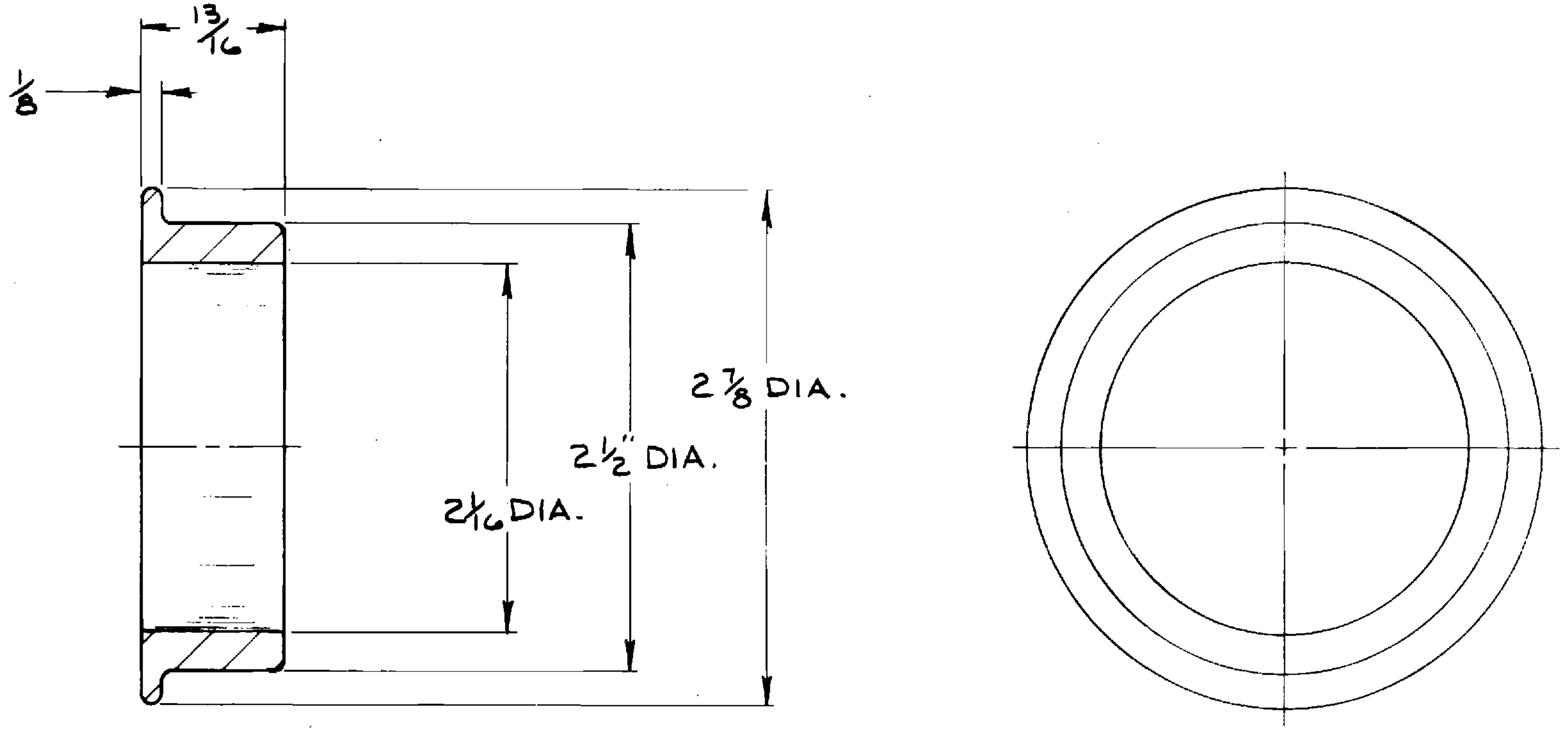
SCALE: 1" = 1" | ACCT. G1320-1 | SHEET 1 OF 1

CAT. 824166 FORM B-7 12-73

NOTES:

1. ALL DRAFT ANGLES TO BE 1½° TO 4°
2. ALL FILLETS & RADII TO BE ⅛" R. UNLESS OTHERWISE SPECIFIED

REVISIONS			
LTR	DESCRIPTION	DATE	APPROVED



APPLICATION			
THIS ITEM IS USED ON SUBASSEMBLIES			
DRAWING NO.	PER ASSY	NO. OF ASSYS	TOTAL
2030	1	1	1
TO MAKE FINAL ASSEMBLY			TOTAL REQ'D.

DO NOT SCALE DRAWING

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES. TOLERANCES ARE: ± 1/32

.XX = – .XXXX = –

.XXX = – ANGLES = –

MATERIAL & TREATMENT

CAST IRON

SIGNATURE	DIV.	DATE
DRAWN BY	653	1-7-76
DRAFTING APPD.		
DESIGN APPD.		
APPD.		
PROJECT APPD.		
SPECIAL APPD.		

BATTELLE MEMORIAL INSTITUTE
COLUMBUS LABORATORIES
505 KING AVE., COLUMBUS, OHIO 43201

TITLE

PLUNGER SPACER

SIZE	CODE IDENT. NO.	DIV. NO.	DWG. NO.	REV.
A	79986	644	2032	

SCALE 1"=1" ACCT G1320-1 SHEET 1 OF 1

CAT. 294163 FORM D-5 5-70

Project A-1894

SECOND PROGRESS REPORT ON THE UTILIZATION/EVALUATION OF AN AID HAND-OPERATED WATER PUMP

Prepared by

The U.S. Agency for International Development

by

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Engineering Experiment Station
GEORGIA INSTITUTE OF TECHNOLOGY
Atlanta, Georgia
January 1978

Table of Contents

* * *

Tables

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Tables (continued)

Maps

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Forms

Acknowledgment

This program of field testing the AID/Battelle hand-operated water pump would never have come into being without the help of many individuals who have supplied large quantities of factual information and have given freely of their time, permitting project personnel to profit from their seasoned judgment. This program does not contractually require active participation by local Agency for International Development Missions in Costa Rica and Nicaragua, but such participation has been given abundantly in the form of personnel, vehicles, coordination of program activities, and insight into local conditions within each country. Personnel of the Ministries of Health in each country have contributed significantly with their own resources of vehicles, tools, and employees possessing noteworthy technical skills, dedication, and professionalism.

While it is impossible to list all individuals who have rendered assistance to the program, the authors of this report would like to especially acknowledge the following:

Dr. Herman Weinstok, M.D., Minister of Health in Costa Rica

Dr. Edmundo J. Bernheim, M.D., present Minister of Health in Nicaragua

Min. Adan Cajina Ríos, previous Minister of Health in Nicaragua

Mr. Stephen E. Knaebel, present Mission Director, USAID/Costa Rica

Mr. Joseph J. Sconce, previous Mission Director, USAID/Costa Rica

Mr. Arthur W. Mudge, Mission Director, USAID/Nicaragua

Dr. James E. Sarn, M.D., Chief Public Health Advisor, USAID/Nicaragua

Mr. Heriberto Rodriguez, General Engineer, USAID/Costa Rica

Mr. Rene Uriza S., Assistant I (Public Health), USAID/Nicaragua

Dr. Guillermo Contreras, M.D., present Director of the Department of Rural Health, Ministry of Health in Costa Rica

Dr. Carlos Eduardo Valerín, M.D., previous Director of the Department of Rural Health, Ministry of Health in Costa Rica

Mr. José María Zúniga, Director of PLANSAR, Ministry of Health in Nicaragua

Mr. Roger Madriz, President of Mecanizados Mofama, the AID pump manufacturer in Costa Rica

Mr. Leonel García Lara, consultant to Cometales, the AID pump manufacturer in Nicaragua

Mr. Jaíro Triano Harker, President of Cometales, the AID pump manufacturer in Nicaragua

Mr. Robert D. Fannon, Jr., of Battelle's Columbus Laboratories, also has been very helpful in supplying working drawings of the AID/Battelle pump and background information on the history of the pump.

Summary

Recognizing the need in developing countries for a constant supply of potable water and the corollary worldwide need for a long-lasting, easily repaired, locally manufactured hand pump, the Agency for International Development (AID) began in 1966 a series of contracts with the Battelle Memorial Institute to design and laboratory test a reciprocating shallow- and deep-well hand pump. A final design was developed and, in late 1976, AID contracted with the Office of International Programs at the Georgia Institute of Technology to evaluate the performance and acceptability of the AID pump in comparison with other pumps used in developing countries and the feasibility of local manufacture of the AID pumps. The program consists of the manufacture of the pumps in Nicaragua and Costa Rica, the purchase of locally available competitive pumps, installation of the pumps in rural villages, and evaluation of the field performance of the pumps over a one-year period. Cooperating with Georgia Tech on the project has been the Central American Research Institute for Industry (ICAITI) and local Ministry of Health and AID officials in Costa Rica and Nicaragua.

Costa Rica

Costa Rica was chosen as a test country because of a sizable well and hand-pump loan that had been made to that country by AID and because of the country's need for an expanded water-pump program. Provisions of the loan specifically included installation of water pumps on a large-scale basis, and it was felt that assistance in such areas as pump selection, installation techniques, and pump maintenance, as a part of this field-test program, would greatly benefit the government of Costa Rica. Costa Rican Ministry of Health and AID officials also strongly felt that a locally manufactured hand pump offered by the AID/Georgia Tech/ICAITI program had many advantages that should be included in the Costa Rican loan program (mainly employment generation, spare parts availability, and lower cost hand pumps than commercially available).

One aspect of this project that has been obvious from the beginning is that, even though Costa Rica is a developing country, it is much more developed than Nicaragua, and this shows up in the availability of rural community water supplies for the two countries. For instance, based on recent surveys,

representative test sites chosen for this project show an average usage by approximately 60 persons in Costa Rica and 170 persons in Nicaragua. In Costa Rica, most communities of 250 inhabitants or more have some form of piped water system, while in Nicaragua, the size of the community will usually exceed 2,000 inhabitants before piped water is found. In Costa Rica, most communities will have at least one well with a pump, if not piped water, and in Nicaragua, springs, rivers, and open, dug wells are the common sources of water. Costa Rica has a greater degree of electrification in rural areas, allowing the installation of motorized pumping systems that are not possible in many areas of Nicaragua. Further, the Ministry of Health in Costa Rica has had a limited hand-pump program for some 15 years, while Nicaragua is just now in the beginning stages of such a program.

Active work began in Costa Rica in January 1977, when AID/Washington and Georgia Tech agreed that Costa Rica and Nicaragua should be the test countries for the program described herein. A machine shop, subcontracting to a local foundry for iron castings, was contracted with for the manufacture of 20 AID pumps (eleven deep-well and nine shallow-well), which were produced and delivered to a Ministry of Health warehouse for storage and installation by Ministry of Health technicians in April. Two different kinds of pumps were chosen with which to compare the AID pump: a Dempster and a Japanese "Lucky" pump. Thirty-one sites, representative of Costa Rica, were chosen to receive the test pumps (16 AID pumps and 15 competitive pumps), most of which already had installed pumps varying in condition from broken to fully operational. (A pictorial monograph of all field-test sites in both Costa Rica and Nicaragua is contained in the Appendix of this report.)

Wells were randomly tested by chemical and bacteriological analyses prior to test-pump installation and found to contain large numbers of intestinal bacteria, indicating that contamination was not being sealed off from the water. The pumps were installed by the Ministry of Health, the wells were disinfected with a chlorine-yielding compound, and attempts were made to seal off the contamination sources. However, subsequent bacteriological testing has shown no improvement in the quality of the water due to poor design and construction of the upper well structures by the rural villagers and Ministry of Health personnel -- a matter that has caused great concern within the Ministry of Health. As a result, internal organizational changes have been made and technicians and engineers are now being hired in an attempt to alleviate the situation.

Nicaragua

Nicaragua was chosen as a test country because of a rural water supply and hand-pump program loan by AID to that country involving the installation of hand-operated water pumps. The loan provisions included potable water systems that will construct 300-340 wells by the end of 1979, which the AID/Georgia Tech program has complemented by providing technical assistance in pump selection, installation techniques, and pump maintenance, and which has enabled the Ministry of Health in Nicaragua to take advantage of locally manufactured hand pumps that can be produced at a cost lower than commercially available pumps. This local program increases spare parts availability, contributes to a positive balance of trade, and stimulates local employment.

As in Costa Rica, program activities began in Nicaragua in January 1977. A local foundry was chosen to manufacture 20 AID pumps (eleven deep-well and nine shallow-well) which were produced and delivered to a Ministry of Health warehouse for storage and installation by Ministry of Health engineers and technicians in May. Two kinds of locally available pumps were chosen to compare the AID pump with: a Dempster and a Brazilian "Marumby" pump. A pump developed by the International Development Research Centre (IDRC) of Ottawa, Canada, was also used for comparison. Thirty sites, representative of Nicaragua, were approved to receive the test pumps (16 AID pumps and 14 comparative pumps), and all of the sites required extensive preparatory work before pumps could be installed. Pumps were installed by a Ministry of Health installation team, and the wells were disinfected with a chlorine-yielding substance. As in Costa Rica, the sites had chemical and bacteriological testing prior to installation of test pumps and showed intestinal bacteria, requiring further testing to determine if the contamination is being sealed out by the addition of a closed well and the use of a hand pump for lifting the water.

Conclusions and Recommendations

Monitoring of pump performance is in an advanced stage of the budgeted 12-month period, and sufficient data are available for arriving at reliable conclusions. There are obvious indications at the present time that <u>most definitely encourage further manufacture, installation, and use of the AID pump</u>. The AID pump can be manufactured in a developing country at a competitive, profitable price and at an acceptable level of quality if adequate facilities (foundries, pattern makers, machine shops and skilled machinists, raw materials, etc.) are available; however, the availability of adequate foundry facilities with acceptable pump prices and quality controls are matters that must be determined for each individual developing country. Public acceptance by rural villagers has been good, both from an aesthetic standpoint and from a standpoint of the pump being used easily by men, women, and children. Further, the AID pump should have a positive impact in developing countries on the health of rural people, on employment generation, on a positive balance of trade, and on instilling national pride within the people when it is seen that these countries do have local capabilities for manufacturing a relatively complicated product rather than importing it.

As indicated above, the AID pump (both the shallow-well and the deep-well version) is adaptable to local manufacture in developing countries if adequate facilities are available. While numerous manufacturing problems have been encountered in both Costa Rica and Nicaragua, the majority of these problems are problems that are to be expected when a product such as the AID pump is introduced into production for the first time. As subsequent orders are processed through the manufacturer's plant and as personnel become more familiar with the pump itself, quality control should be refined to the point where the orders are considered to be normal production.

Comparative pumps used in this field test were originally chosen because they were expected to hold up well during the test period. The Dempster pump is an extremely fine pump and has performed remarkably well but is rather expensive. The Brazilian "Marumby" pumps are beginning to fail and have been disappointing in their durability. The IDRC pump has good points that represent a lower level of technology than that required of the AID pump and is an alternative to the AID pump, especially where foundry facilities are not available but local manufacturing is desirable. The Japanese "Lucky" pump has performed extremely well but is a complicated pump and will, undoubtedly, present maintenance problems as the components begin to wear.

Lastly, this program of field testing the AID pump has presented many unforeseeable problems. However, the satisfaction of providing a means of safe, convenient water during this test period to rural villagers that heretofore have been getting their water from grossly polluted sources or have been walking many miles per day for small amounts of water necessary to survive on has made each and all of the problems seem insignificant. As a result, Georgia

Tech and ICAITI project personnel are grateful to the Agency for International Development for the opportunity to have participated in such a program.

INTRODUCTION

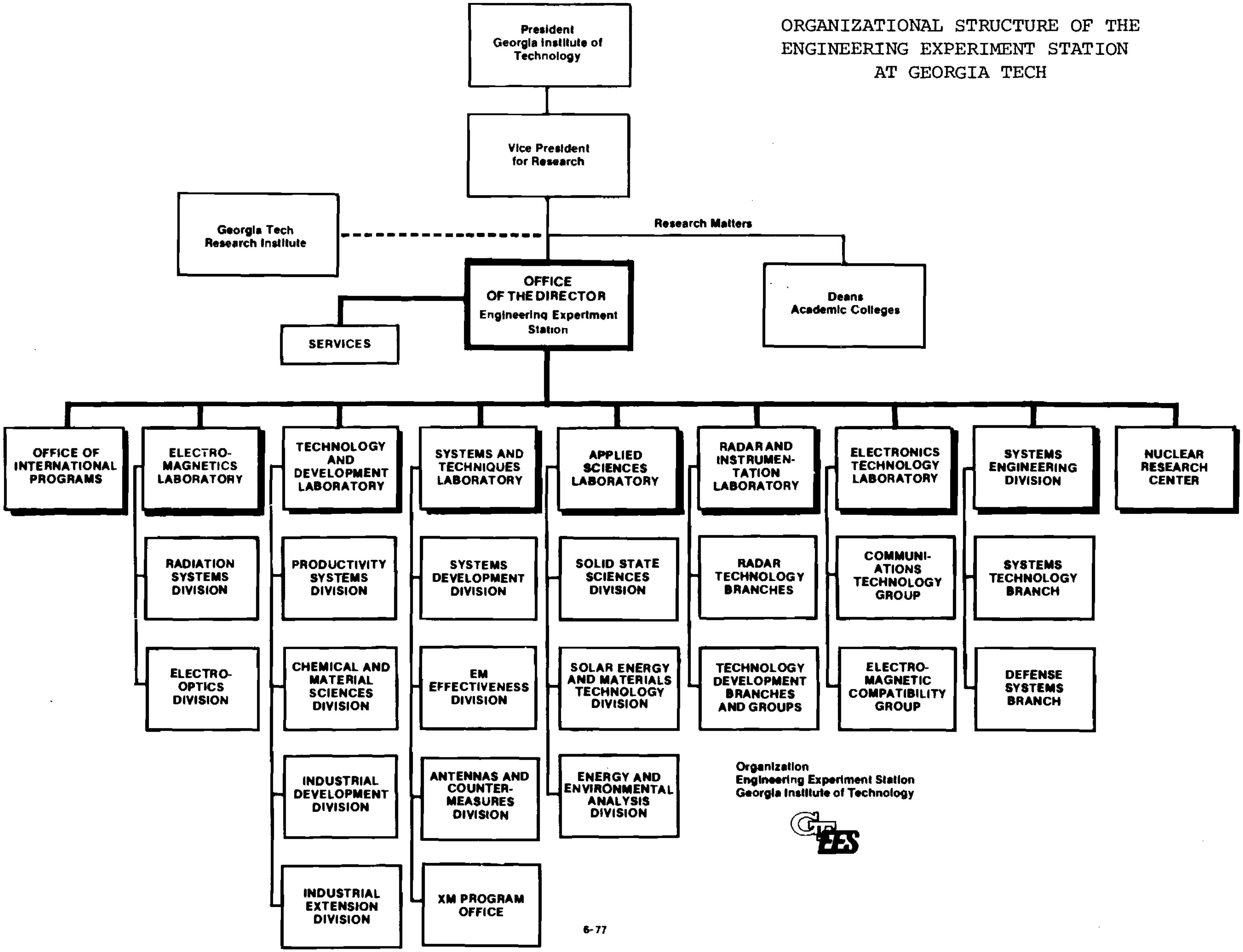
Recognizing the need in developing countries for a constant supply of potable water and the corollary worldwide need for a long-lasting, easily repaired, locally manufactured hand pump, the Agency for International Development (AID) began in 1966 a series of contracts with the Battelle Memorial Institute to design and laboratory test a reciprocating shallow- and deep-well hand pump. A final design was developed and, in late 1976, AID contracted with the Office of International Programs at the Georgia Institute of Technology to evaluate the performance and acceptability of the AID pump in comparison with other pumps used in developing countries and the feasibility of local manufacture of the AID pumps. Cooperating with Georgia Tech on the project has been the Central American Research Institute for Industry (ICAITI) and local Ministry of Health and AID officials in Costa Rica and Nicaragua.

The program consists of the manufacture of the pumps in Nicaragua and Costa Rica, the purchase of locally available competitive pumps, installation of the pumps in rural villages, and evaluation of the field performance of the pumps over a one-year period. One manufacturer in each country was selected to manufacture the AID pump. A minimum of 15 AID pumps and 14 locally available pumps of various kinds have been installed in each country, and detailed, frequent monitoring of their operation is now under way.

Organizationally, Georgia Tech has had overall responsibility for the AID water-pump field testing. Members of the Engineering Experiment Station have been, and are currently, involved in national and international programs of community and area development, management and technical assistance to business and industrial firms, industrial and economic development training, market analyses, studies of new manufacturing opportunities, manpower resources and labor productivity, stimulation of small scale industry, technology assessment, development and conservation of energy resources, housing resources, industrial economics, economic uses of industrial wastes, adaptive technology research and development, audiovisual presentations and multimedia documentation, and professional guidance in planning industrial and economic development programs. The organization of the Engineering Experiment Station is illustrated in Figure 1.

Figure 1

ORGANIZATIONAL STRUCTURE OF THE
ENGINEERING EXPERIMENT STATION
AT GEORGIA TECH



ICAITI, chosen as a Central American counterpart by Georgia Tech to enable efficient utilization of travel funds, to provide quick response to AID and to the Ministries of Health in Costa Rica and Nicaragua, and to take full advantage of its established working relationships with existing communities, industries, lending institutions, and governmental departments of Costa Rica and Nicaragua, is very similar to the Engineering Experiment Station. For more than 14 years, ICAITI has made significant contributions to the industrial development of Central America and also has completed a considerable number of related projects that have aided in the accomplishment of this program.

The program, more specifically, has consisted of participation by Georgia Tech and ICAITI in the following activities:

1. Providing technical assistance for selected foundries and machine shops to locally manufacture the AID pump.
2. Selecting and purchasing locally available pumps to be used in comparison with the AID pump.
3. Selecting 60 field-test sites for installation of 30 AID pumps and 30 locally available pumps (30 sites located in each of the two test countries).
4. Determining the quality of water through chemical and bacteriological analysis.
5. Preparing sites (preparing new wells or rehabilitation of existing wells, as necessary).
6. Installing pumps.
7. Monitoring pump performance for a 12-month period.
8. Collecting and analyzing field data.

In gathering and analyzing data on the AID pump, seven areas have been of major concern:

1. Operational performance in the field.
2. Maintenance requirements and pump reliability.
3. Competitive cost and analysis of the economics of in-country manufacturing.
4. Manufacturing problems encountered.

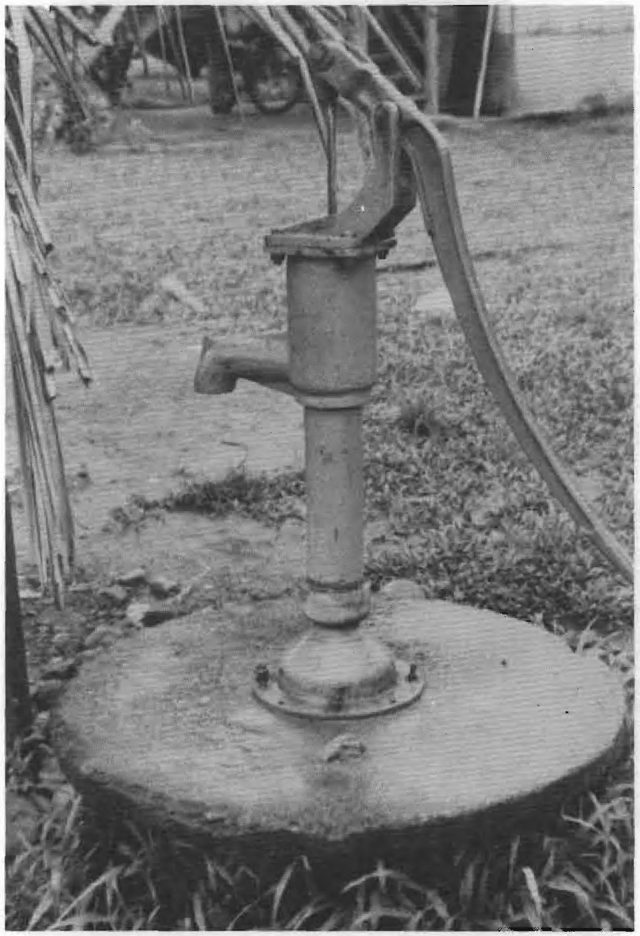
5. Needed design changes and future utilization.

6. Public acceptance and marketability.

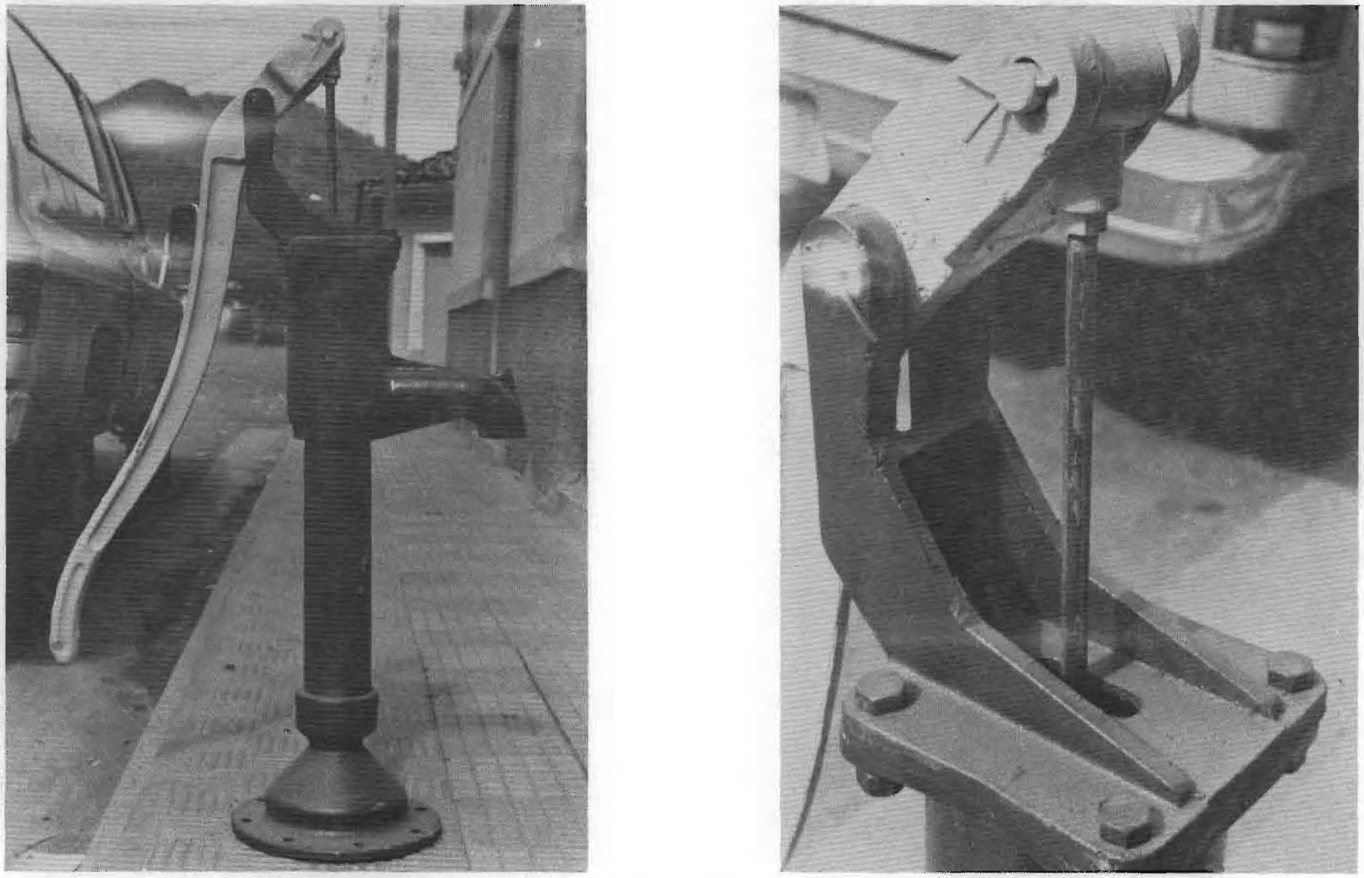
7. AID pump design characteristics and specifications.

The program indicates, at this time, that the AID pump is very adaptable to local manufacture in many developing countries and offers many benefits (employment generation, spare parts availability, easy maintenance, low cost, and durability). The AID pump consists of a shallow-well version (the plunger, or piston, and its cylinder located above the water level) and a deep-well version (the plunger, or piston, and its cylinder located below the water level). Both versions are single action, reciprocating, positive displacement type pumps. Photographs of these pumps, produced both in Costa Rica and in Nicaragua, follow.

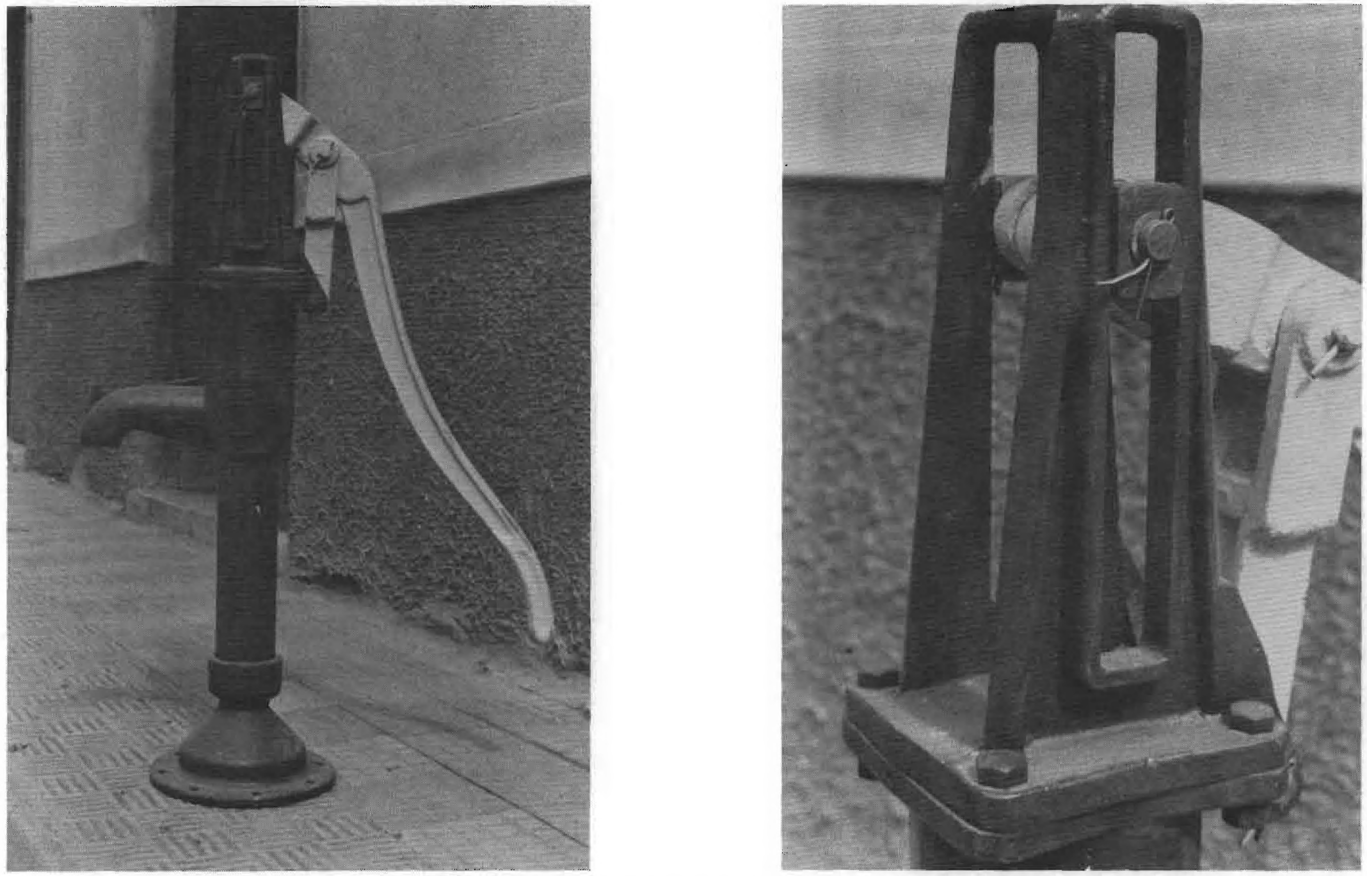
COSTA RICA



The AID shallow-well pump, left photo, and the AID deep-well pump, right photo, both manufactured in Costa Rica.



The AID shallow-well pump, manufactured in Nicaragua



The AID deep-well pump, manufactured in Nicaragua

COSTA RICA

Background

It is universally accepted that an adequate supply of water for drinking, personal hygiene, and other domestic purposes and an adequate means of waste disposal are essential to public health and well-being. Unfortunately, vast numbers of people in the developing world, most of them living in rural areas, do not have access to a safe and convenient source of water. When safe and convenient sources are available, satisfactory sewage disposal facilities normally are still unavailable.[1/]

Costa Rica was chosen as a test country because of a sizable well and hand-pump loan that had been made to that country by AID and because of the country's need for an expanded water-pump program. Provisions of the loan specifically included installation of water pumps on a large-scale basis, and it was felt that assistance in such areas as pump selection, installation techniques, and pump maintenance, as a part of this field-test program, would greatly benefit the government of Costa Rica. Costa Rican Ministry of Health and AID officials also strongly felt that a locally manufactured hand pump offered by the AID/Georgia Tech/ICAITI program had many advantages that should be included in the Costa Rican loan program (mainly employment generation, spare parts availability, and lower-cost hand pumps than commercially available).

One aspect of this project that has been obvious from the beginning is that, even though Costa Rica is a developing country, it is much more developed than Nicaragua, and this shows up in the availability of rural community water supplies for the two countries. For instance, based on recent surveys, representative test sites chosen for this project show an average usage by approximately 60 persons in Costa Rica and 170 persons in Nicaragua. In Costa Rica, most communities of 250 inhabitants or more have some form of piped water system, while in Nicaragua, the size of the community will usually exceed 2,000 inhabitants before piped water is found. In Costa Rica, most communities will have at least one well with a pump, if not piped water, and in Nicaragua,

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1/ Robert J. Saunders and Jeremy J. Warford, Village Water Supply, (Baltimore, Maryland: The Johns-Hopkins University Press, 1976), p. 3.

springs, rivers, and open, dug wells are the common sources of water. Costa Rica has a greater degree of electrification in rural areas, allowing the installation of motorized pumping systems that are not possible in many areas of Nicaragua. Further, the Ministry of Health in Costa Rica has had a limited hand-pump water program for some 15 years, while Nicaragua is just now in the beginning stages of such a program.

This does not mean that Costa Rica is without a need for improvement in its potable water delivery system. The Ministry of Health, for instance, has estimated that as many as 47,000 hand-operated water pumps are needed to provide a suitable water supply to the country's rural citizens. Further, many existing water pumps are inoperable because of a lack of maintenance and, where there are functioning pumps, most of the well structures are poorly designed and completely ineffective in sealing out contamination. There is also a great need for a proper governmental organization infrastructure that does not now exist to carry out an effective rural water supply program.

Active work began in Costa Rica in January 1977, when AID/Washington and Georgia Tech jointly agreed that Costa Rica and Nicaragua should be the test countries for the program described herein. A machine shop, subcontracting to a local foundry for iron castings, was contracted with for the manufacture of 20 AID pumps (eleven deep-well and nine shallow-well), which were produced and delivered to a Ministry of Health warehouse for storage and installation in April. Two different kinds of pumps were chosen with which to compare the AID pump: a Dempster and a Japanese "Lucky" pump. Thirty-one sites, representative of Costa Rica, were chosen to receive the test pumps (16 AID pumps and 15 competitive pumps), most of which already had installed pumps varying in condition from broken to fully operational. (A pictorial monograph of all field-test sites in both Costa Rica and Nicaragua is contained in the Appendix of this report.)

Wells were randomly tested by chemical and bacteriological analyses prior to test-pump installation and found to contain large numbers of intestinal bacteria, indicating that contamination was not being sealed off from the water. The pumps were installed by the Ministry of Health, the wells were disinfected with a chlorine-yielding compound, and attempts were made to seal off the contamination sources. However, subsequent bacteriological testing has shown no improvement in the quality of the water due to poor design and construction of the upper well structures by the rural villagers and Ministry of Health personnel -- a matter that has caused great concern within the Ministry of Health. As a result internal organizational changes have been made and technicians and engineers are now being hired in an attempt to alleviate the situation.

Field Test Sites

Table 1 shows those sites selected for the field testing in Costa Rica and which were chosen primarily because of their relative high usage (for Costa Rica) and accessibility. All sites were existing wells, all except one had been hand dug rather than drilled, and all were classified as either deep wells (as used herein, more than 25 feet in depth) or shallow wells (25 feet or less in depth). The usage at each site varied considerably, with an overall average of 60 people. Approximately half of these sites already had pumps, with the condition of the original pumps ranging from broken and inoperable to good. (The other half of the well sites had no previous pumps and, as a result, the new pumps replaced the bucket and rope system of retrieving water.)

Selection of the sites was made during the dry season months of January, February, and March so that the water column figures would indicate annual low-water levels. However, the dry season of 1976-1977 took a disastrous toll on the sites, and, by the middle of May, many (approximately 50%) of the sites had dried up completely and had to be deepened before all pumps could be installed. In some cases, the wells had already been dug as deeply as possible, and substitute sites had to be found that were much more inaccessible and less desirable from a high-usage standpoint.

The general areas of site concentration are in the northwestern quadrant of Costa Rica in the vicinity of Nicoya, Santa Cruz, Liberia, and Las Canas, and in the eastern area of Limon (see Map 1).

Manufacture of AID Pumps

Manufacturing Costs. A contract was signed with Mecanizados Mofama, S.A., located near San Jose, on January 28, 1977, for the manufacture of nine shallow-well type AID pumps and eleven deep-well type AID pumps. The prices of the pumps were as follows:

Table 1

SELECTED SITES FOR AID PUMP FIELD TESTS IN COSTA RICA

Site No.	Location	Well Situation	Well Type	Classification by Depth	Depth (m)	Average[1] Estimated Usage - No. People	Type of Original Pump	Condition of Original Pump	Has Water Meter	Type[2] of Pump Installed	Date Installed
1	La Palma de Abangares	Existing	Dug	Deep	11.55	70	Japanese	Broken		AID-DW	4/22/77
2	San Joaquin de Abangares	Existing	Dug	Deep	11.70	38	Dempster	Broken		AID-DW	4/22/77
3	IMAS, El Torito, Samara	Existing	Dug	Shallow	5.86	98	Dempster	Good	X	AID-SW	5/17/77
4	Hernandez de Santa Cruz	Existing	Dug	Shallow	4.30	51	Dempster	Good		Lucky	5/18/77
5	Curime de Nicoya (School)	Existing	Dug	Deep	10.35	125	Dempster	Poor		Dempster	5/19/77
6	Pijije de Bagaces (School)	Existing	Dug	Deep	10.80	38	Dempster[3]	Good		Dempster	5/19/77
7	La Javilla de Canas (School)	Existing	Dug	Shallow	6.10	91	Dempster	Poor		AID-SW	5/20/77
8	Zent #1, Matina (School)	Existing	Dug	Shallow	4.50	60	None	--	X	AID-SW	5/20/77
9	Corina, Matina	Existing	Dug	Shallow	7.60	17	Japanese	Poor		AID-SW	5/25/77
10	Bristol, Matina	Existing	Dug	Shallow	3.20	145	None	--	X	AID-SW	5/26/77
11	La Margarita, Bataan (School)	Existing	Dug	Shallow	3.85	41	None	--		Lucky	5/26/77
12	Corazon de Jesus	Existing	Dug	Deep	12.10	13	None	--		Dempster	6/1/77
13	Zent #2, Matina (Pedro Bustos)	Existing	Dug	Shallow	4.20	15	None	--		AID-SW	6/7/77
14	San Miguel de Venado	Existing	Dug	Deep	14.85	51	None	--		Dempster	6/15/77
15	Sabalito de Venado	Existing	Dug	Deep	19.10	24	None	--		Dempster	6/16/77
16	Pueblo Nuevo de Colorado (School)	Existing	Dug	Shallow	7.48	32	Dempster	Fair	X	AID-SW	6/22/77
17	San Francisco, Santa Cruz (School)	Existing	Dug	Shallow	6.30	30	Dempster	Fair		Lucky	6/23/77
18	Terciopelo de Nicoya	Existing	Dug	Deep	7.61	50	Dempster	Poor		AID-DW	6/24/77
19	Caimitalito de Nicoya (School)	Existing	Dug	Deep	10.50	34	Red Jacket	Broken		AID-DW	6/24/77
20	Judas de Chomes	Existing	Dug	Deep	9.85	118	Dempster	Broken	X	Dempster	8/12/77
21	Limonal de Abangares	Existing	Dug	Deep	9.30	30	Dominion	Broken		Dempster	9/2/77
22	Zent #3, Matina (Mariano Grijalba)	Existing	Dug	Shallow	4.90	8	None	--		Lucky	6/7/77
23	Santa Marta de Matina	Existing	Dug	Shallow	4.10	42	Dempster	Broken		Lucky	7/27/77
24	Tarcolesa de Orotina (School)	Existing	Dug	Shallow	4.30	32	Dempster	Fair		Lucky	8/4/77
25	Mesetas Abajo (School)	Existing	Dug	Shallow	6.30	15	None	--		Lucky	8/5/77
26	San Juan Grande	Existing	Dug	Deep	9.30	153	None	--		AID-DW	8/5/77
27	Sabana Grande	Existing	Dug	Deep	8.30	245	Dempster	Broken		AID-DW	8/10/77
28	Coyolito de Santa Cruz	Existing	Drilled	Deep	10.00	65	Dempster	Broken		AID-DW	8/11/77
29	La Lorena de Santa Cruz	Existing	Dug	Deep	9.60	28	None	--		Dempster	8/12/77
30	Lajas de Canas	Existing	Dug	Deep	10.00	19	None	--		AID-DW	8/29/77
31	Indiana Tres, Siquirres	Existing	Dug	Shallow	3.25	40	None	--		AID-SW	9/8/77

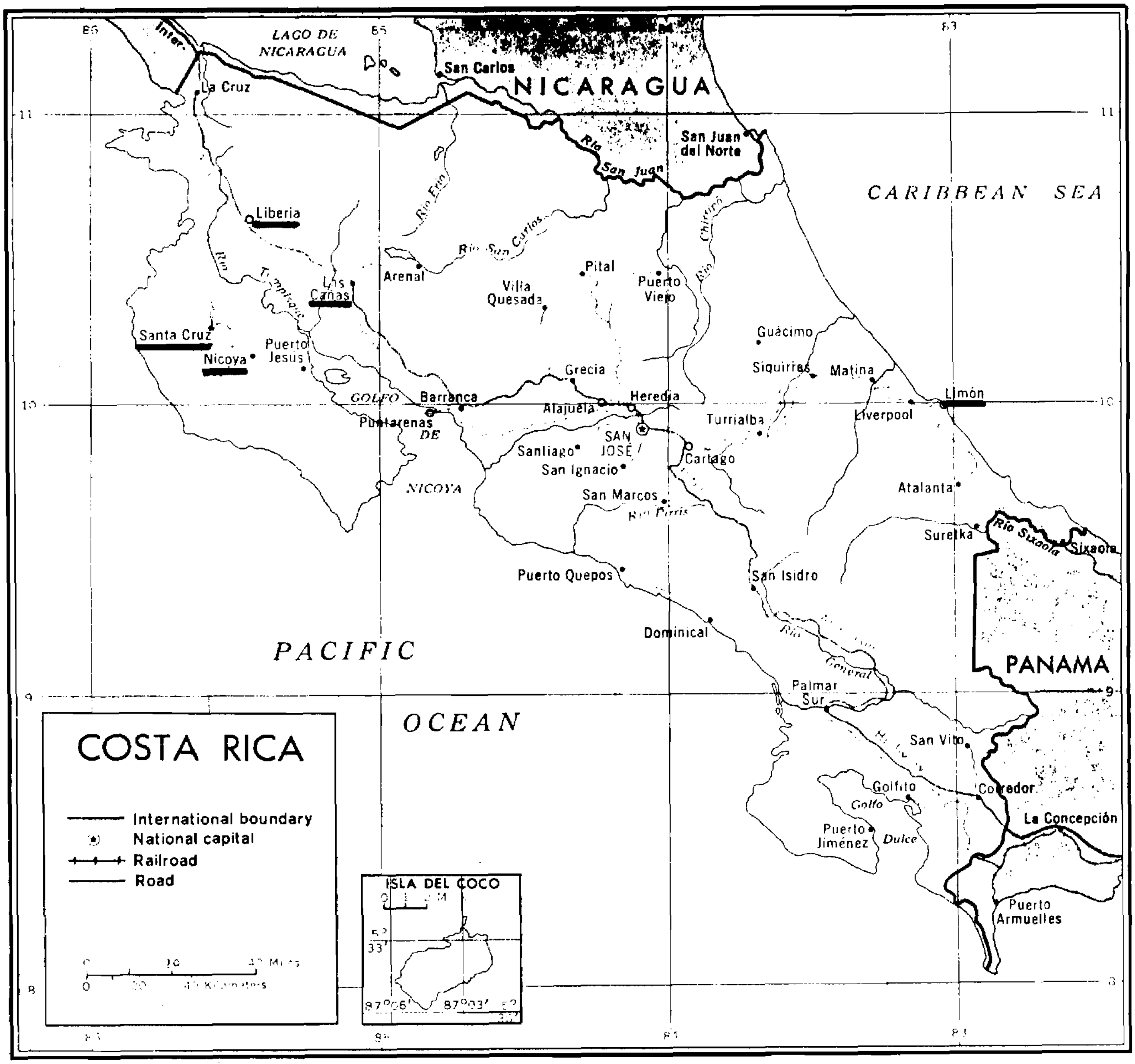
[1] Average estimated usage based upon individual user pattern surveys at each site.

[2] AID-DW: AID pump for deep well; AID-SW: AID pump for shallow well; Dempster: Dempster deep-well type pump; Lucky: Japanese-made shallow-well type pump.

[3] Pump being used for forced pumping to storage tank.

Map 1

COSTA RICAN TEST SITE AREAS



Sites in Costa Rica are concentrated in two major areas: (1) the northwestern quadrant around Nicoya, Santa Cruz, Liberia, and Las Canas, and (2) the eastern area of Limon.

Shallow-well	\$ 98 (each)
Deep-well	\$128 (each)
Patterns	\$498 (one-time charge only)

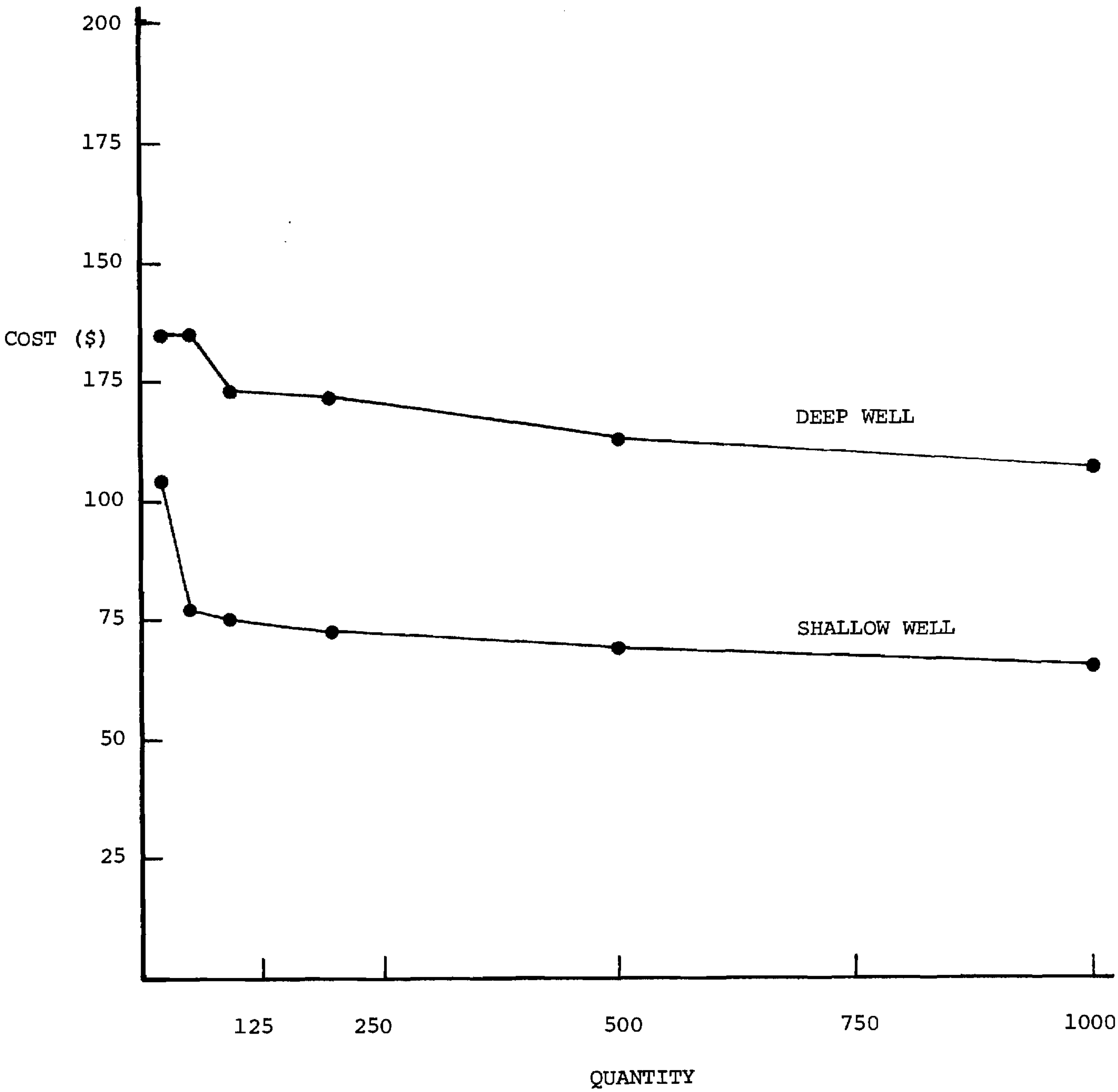
Because an order for 20 pumps does not offer any significant economies of scale, it is terribly costly to manufacture such a small order, especially if the manufacturer is not familiar with the many components of the pump and how they relate to each other. The manufacturer broke even on the 20 pumps actually produced and has updated his prices to reflect a 5% profit and for larger numbers of pumps per order:

Quantity	Shallow-well (\$ Price/Unit)	Deep-well (\$ Price/Unit)
20	103	134
50	77	134
100	75	123
200	72	120
500	68	113
1,000	65	107

The above price scales, represented graphically in Figure 2, show the high cost of small orders. However, as the quantity of pumps ordered increases beyond 100 or more pumps, the price per unit approaches a level that is both competitive and attractive, especially when compared to the constantly rising prices for pumps that are presently being imported into Costa Rica. There are other foundries in Costa Rica that can and probably will be used for future orders to meet the 47,000 pump demand, mentioned earlier, and it is felt that the prices quoted by Mecanizados Mofama can be improved upon. These other foundries were not originally interested in 20-pump orders but have been asked to express their interest in larger orders of the AID pump by submitting formal quotes, and this information will be available soon. Considering the importance of spare parts availability, employment generation, and foreign trade balance of payments, the prices quoted to date are considered to be especially lucrative by project personnel, AID officials in Costa Rica, and Ministry of Health personnel that have installed the AID pumps. Further research and development through value engineering (a method of improving the value of the pump by improving the relationship between its function and its cost) could also lead to lower-cost possibilities.

Figure 2

COST BY QUANTITY TO PRODUCE
AID PUMPS IN COSTA RICA



It should be noted that it has been very difficult during this program to arrive at a "representative" price for the AID pump because of extreme variances in manufacturing costs, especially overhead, between different countries and even between different manufacturers within the same country. For example, in Nicaragua, prior to placing an order with the manufacturer, price quotes were received from seven foundries that ranged from $69 (shallow-well) and $75 (deep-well) to $225 (shallow-well) and $250 (deep-well). During a trip to Ghana, the project director for this program discussed the AID pump with AID and Ghanian government officials and discovered that prior investigations into the use of the AID pump for that country indicated a cost of approximately $500 per pump (shallow-well or deep-well) for a relatively large order (100 pumps or more). Inquiries into the manufacture of the AID pump in the Dominican Republic have provided cost estimates ranging from $72 (shallow-well) and $82 (deep-well) to $162 (shallow-well) and $204 (deep-well).

To complicate matters even more, a judgment of expected quality must be balanced against the price of the pump and, in some cases, higher prices have not necessarily reflected a potential for the highest level of quality. However, the various cost estimates show that the AID pump (shallow-well or deep-well) can be provided for an attractive price of below $100. Further, it is the opinion of the authors of this report that if a particular country has an unusually high demand for water pumps, the AID pump conceivably can be manufactured for as low as $50 (for instance, 50,000-100,000 pumps required over a period of five to ten years).

Manufacturing Specifications. The AID pumps were manufactured according to AID-approved Battelle drawings contained in the Appendix to this report and with the following additional instructions:

1. The plunger rod was made from 1/2-inch diameter rod, rather than 7/16-inch, because of difficulty in locating a reliable supply of 7/16-inch stock. The pump rod nut, the rod end, and the plunger assembly also were changed to accommodate the 1/2-inch plunger rod.

2. The handle pivot pins were hardened to 40 R_C and steel bushings were (60-64 R_C) inserted in the pump handle holes. By taking this approach, the pins are expected to wear out before the handles, allowing easier repairs at the least cost.

3. For the shallow-well pump, the 3-inch support pipe was internally coated with epoxy for a smoother surfaced cylinder finish. Option A (drawing No. 2001), using the bolted pump cap, was chosen in preference to a pin-mounted pump cap.

4. For the deep-well pump (drawing No. 2002), Option A was chosen, using the bolted pump cap in preference to a pin-mounted pump cap. The pump cap was modified, however, because of concern by the manufacturer that he could not cast this particularly complex part. (Figures 3 and 4 are working drawings of the locally modified cap and its accompanying handle fulcrum.) The pump cylinder was constructed from standard PVC pipe.

In addition to the above, all pumps were painted with an anticorrosive coating and consecutively numbered for identification purposes. In general, the manufacturing problems encountered were mostly associated with those to be expected from unfamiliarity with the pump itself on the first production order -- a prototype would have been very helpful -- and from poor castings. Quality control checks were carried out at periodic stages of production by Georgia Tech and ICAITI personnel, and, before acceptance of the finished pumps, all pumps were installed over a 55-gallon drum of water and checked for overall pump performance.

It should be noted that the foundry producing the castings had no laboratory facilities and used scrap metal as the source of raw materials. High quality castings require a level of technology not generally expected to be found in developing countries and, without this technology, quality (such as degree of hardness) will vary from pump to pump and from one production order to the next. As a result, the pump castings produced in Costa Rica are rough in texture, contain voids and inclusions, and would be considered unacceptable by U.S. standards. However, the castings appear to be typical of what is presently available in Costa Rica and, more importantly, they seem good enough for meeting stressing that has been experienced in the field.

Proper machine shop facilities and skilled machinists also are necessary for the manufacture of the AID pump. While the Costa Rican AID pump manufacturer had only a small shop (four employees) for the machining operations required, it was sufficient for pump production. The machine shop contained a multiple-speed lathe, a vertical lathe, welding equipment, a drill press, a metal cutter, and assorted hand tools. Sandblasting equipment was not available

Figure 3

MODIFIED DEEP-WELL PUMP CAP
IN COSTA RICA

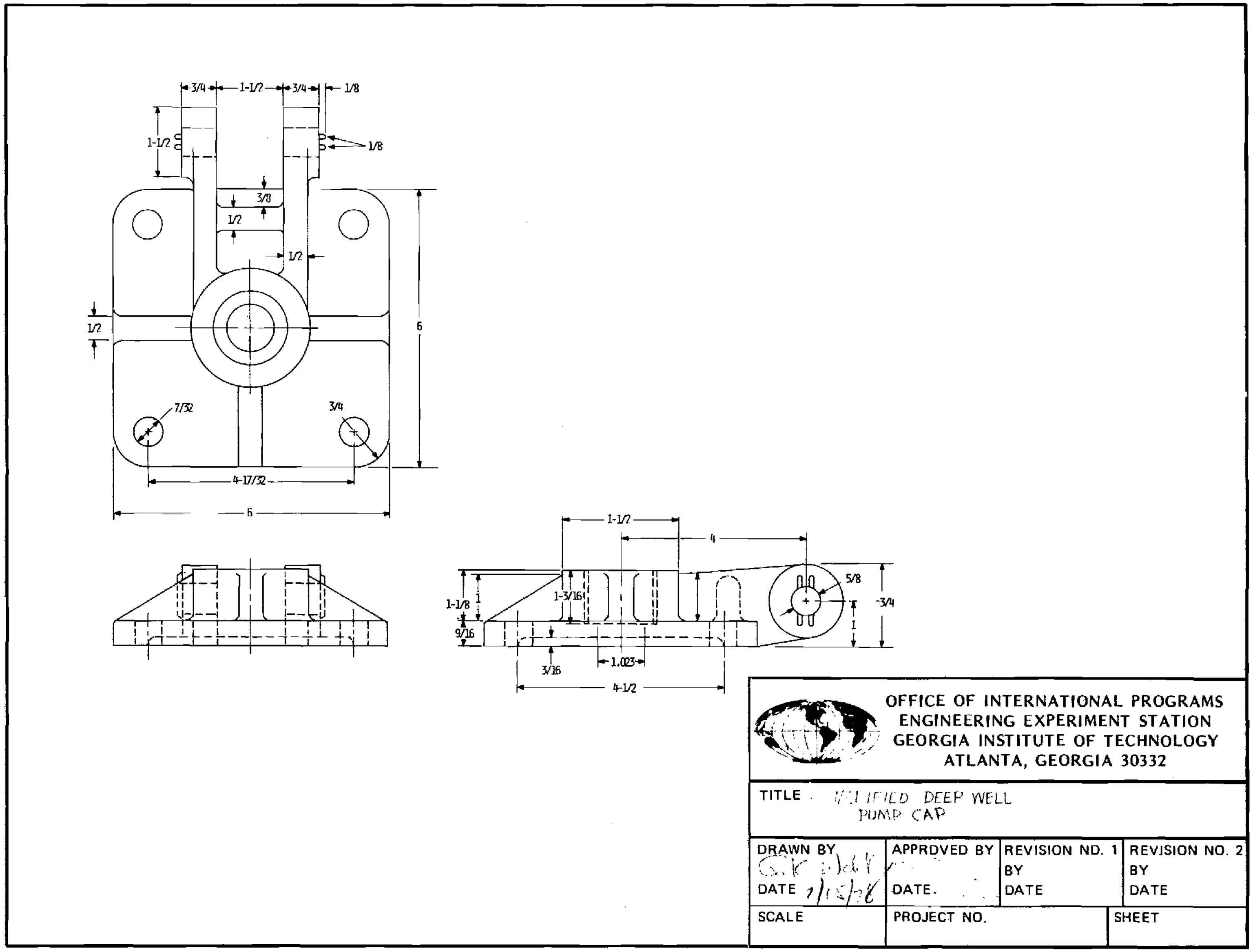
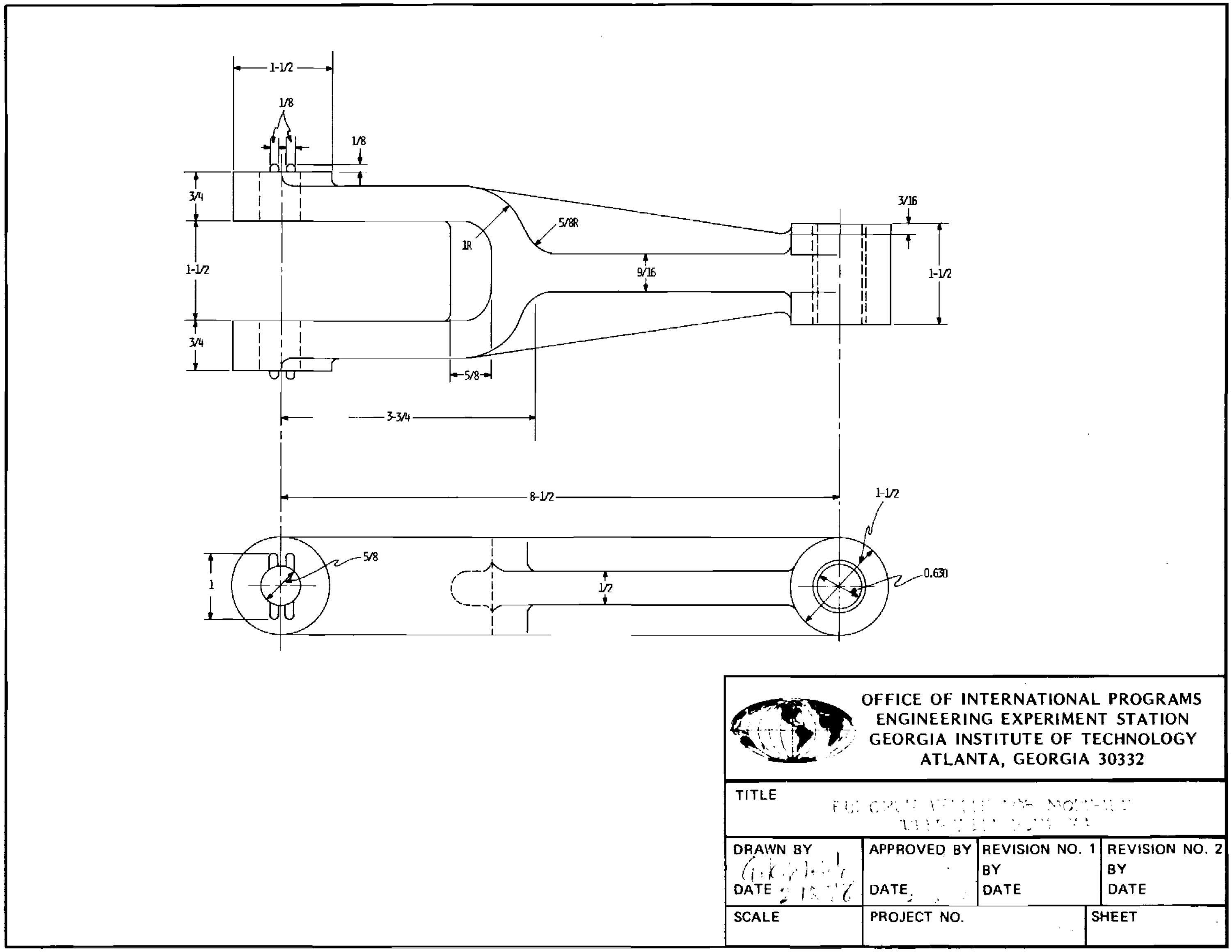


Figure 4

FULCRUM HANDLE FOR MODIFIED DEEP-WELL
PUMP CAP IN COSTA RICA



but would have been useful in smoothing out the rough texture of the castings. Additionally, the machine shop did not have access to an oven, which was necessary for hardening the steel bushing inserts and the handle pivot pins (a competitor's oven was actually used).

Comparative Pumps

Two pumps were chosen for comparison with the AID pumps manufactured in Costa Rica -- a Dempster and a Japanese Kawamoto Daiichi "Lucky" pump. The Dempster model (see Figure 5) is considered by the authors of this report to be one of the better hand-operated water pumps in the world, has the cylinder below water level so that it can be used for wells of shallow or deep depth, and costs approximately $257 (1977 prices) in Central America, delivered (the $257 includes the pump, the cylinder, and transportation). The "Lucky" pump (see Figure 6) is for shallow wells only (25 feet or less in depth), appears to be of good quality, has a porcelain-lined cylinder, and costs approximately $63 in Central America, delivered.

Monitoring System

Responsible individuals in each test community have been provided with simple, printed report forms (see Form 1) designed to provide information covering community usage, pump physical condition, and functioning problems, if any. These forms are filled out and returned to Ministry of Health representatives every 15 days. If the returned forms show complaints of any type concerning pump functioning or condition, a repair truck is dispatched to the site for investigation and repair of the defect. Should a serious pump failure occur that cannot be corrected readily by Ministry personnel, the Ministry has been instructed to request immediate assistance from Georgia Tech or ICAITI by telephone.

Copies of all report forms, as well as a record of any repair work done on either AID or competitive pumps, are maintained at the Ministry of Health. This information is reviewed periodically by ICAITI for inclusion in pump performance control charts. In addition to the above, a site-by-site inspection of all pumps has been made approximately every 30 days by Georgia Tech and/or ICAITI personnel.

Figure 5

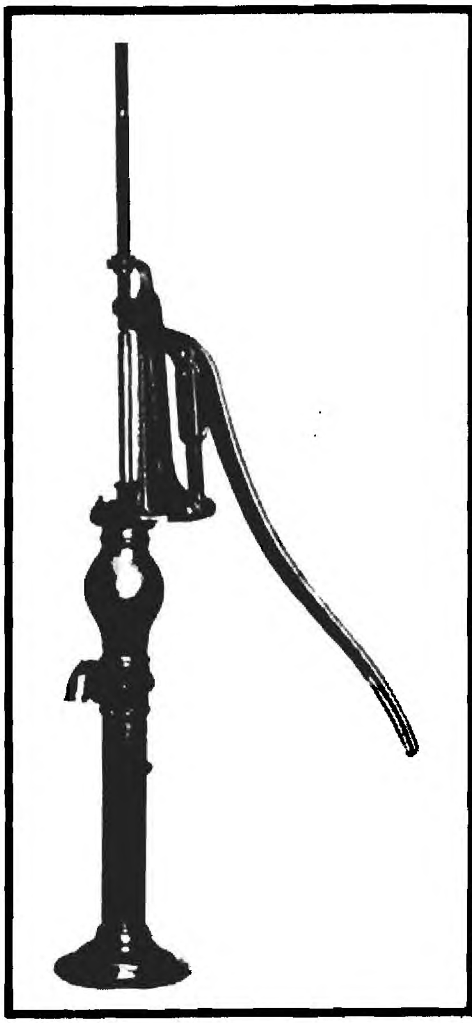
PUMPS and CYLINDERS

DEMPSTER®

CONSTRUCTION

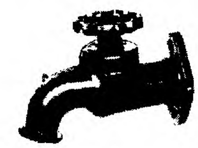
DATA SHEET 380-3
ISSUE DATE 1976

CAST IRON



MODEL 210F

Dempster hand and windmill pumps are adapted for wells of any depth. Neat in design and substantially built, equipped with a 4-bolt adjustable flanged top, extra long handles and heavy steel bearer pins. Tops fitted with stuffing box and packing for tight seal on the piston rod. 4-position handle adjustment for up to 10 inch stroke. Large capacity air chamber for smooth force pumping. Furnished with syphon or compression spout. Syphon spout furnished unless otherwise ordered. 2 x 1-1/4-inch suction bushing furnished with each pump.



MODEL 36
Compression Spout
Furnished at slight Additional Cost.

MODEL 226F

MODEL 210F is a heavy-duty hand or windmill force pump. It has a 1-1/16-inch polished steel piston rod securely threaded to the flat bar. For wells of extreme depth, with large cylinders or continuous operation. This model is available with 2-1/2-inch tapping in the base at slight additional cost.

Type	Hand & Windmill
Suction Tapped	2 in.
Piston Rod Threaded for,	
Rod	7/16 in.
Pipe	3/8 in.
Tapping in Rear	1¼ in.
Approx. Weight	71 lbs.

MODEL 210F(CS) same as Model 210F except equipped with Model 36 Compression Spout.

MODEL 226F is normal duty hand or windmill force pump. It has a 11/16 inch steel piston rod fitted to the flat bar with a heavy cast set screw connection. For wells of shallow to moderate depth at normal farm and ranch operation.

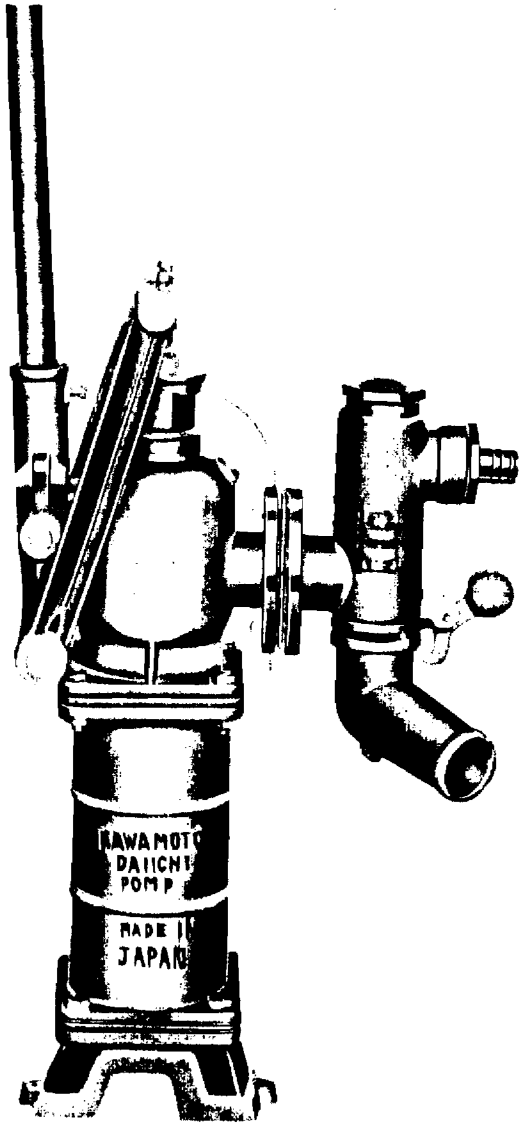
Type	Hand & Windmill
Suction Tapped	2 in.
Piston Rod Threaded for,	
Rod	7/16 in.
Pipe	3/8 in.
Tapping in Rear	1¼ in.
Approx. Weight	70 lbs.

MODEL 226F(CS) same as Model 226 F except equipped with Model 36 Compression Spout.

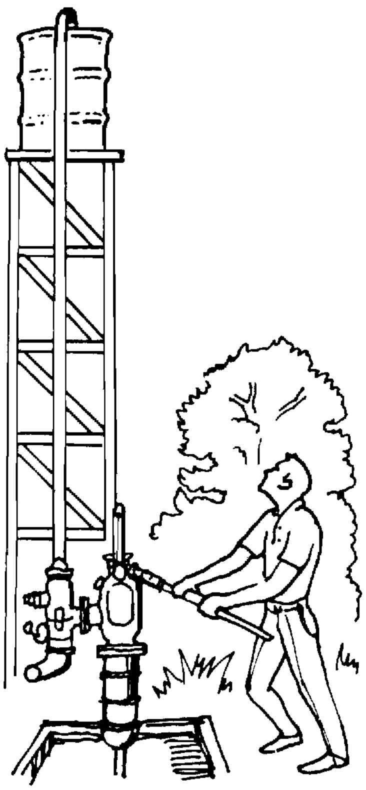
DEMPSTER INDUSTRIES INC., Beatrice, Nebraska 68310 (402) 223-4026

Figure 6

LUCKY PUMP

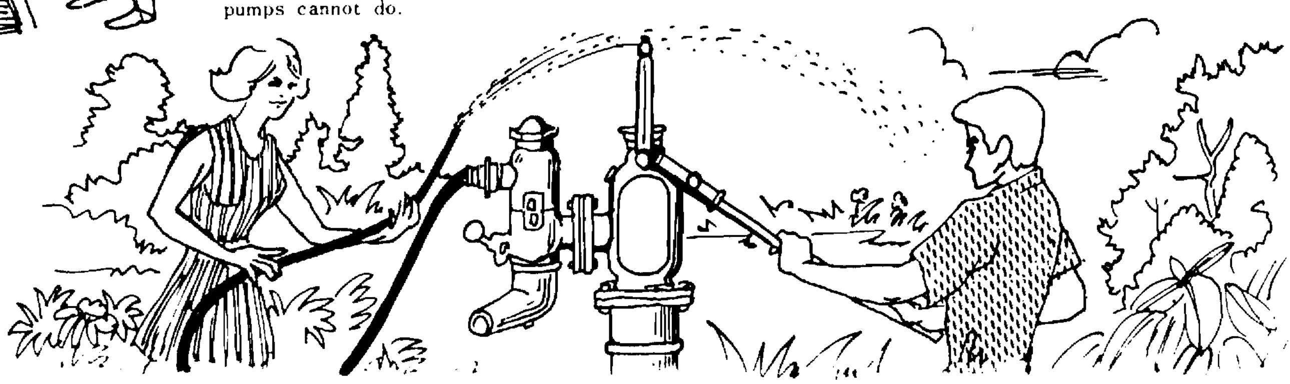


- The most outstanding and unique feature of the "LUCKY" Hand Pump is the ConVertibility in its usage from an ordinary suctioning to pushing up water as illustrated.
  No other brand of hand pump offers this double usage. Thus, it makes "LUCKY" a very economical buy, "TWO PUMPS FOR THE PRICE OF ONE"

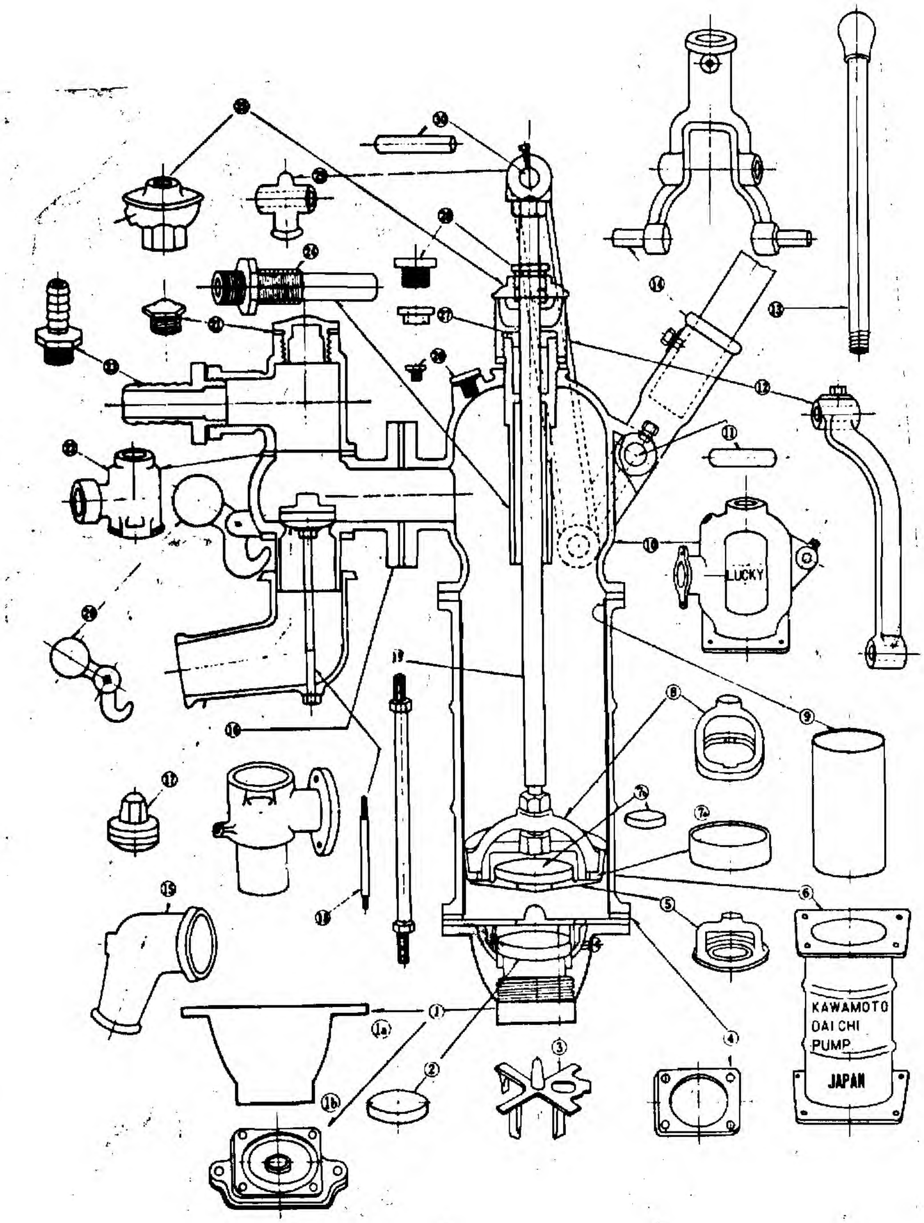


Special Features:

1. Chrome Pump Rod: A special hard chrome around the pump rod gives "LUCKY" added durability. Only gun-metal and steel used in main parts and casted with the best pig iron.
2. Porcelain Enameled Cylinder Liner: Unlike other pumps, "LUCKY" has a porcelain enameled cylinder liner which prevents rusting of the pump lining. Very little physical effort is required to get maximum amount of water in less time.
3. Leakage Impossible: A special double gland packing prevents water leakage which is very common in other kinds of pumps.
4. Vertical Pumping Motion: This kind of pumping motion makes it easy to connect the pump rod of the artesian wells, without any alteration.
5. Mud Free : The unique construction of "LUCKY" pumps eliminates mud which ordinary pumps cannot do.

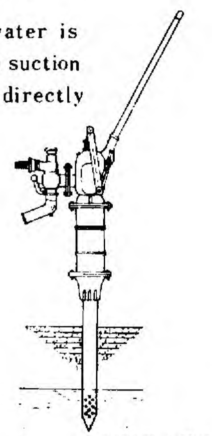


(1a) DRIVEN SUCTION VALVE BOX
(1b) DUG SUCTION VALVE BOX
(2) VALVE
(3) VALVE GUIDE
(4) RUBBER PACKING
(5) LOWER PISTON
(6) CYLINDER
(7a) BOWL RUBBER
(7b) PISTON VALVE
(8) UPPER PISTON
(9) SLEEVE PORCELAIN ENAMELED
(10) CHAMBER
(11) HANDLE PIN
(12) DOUBLE ROD
(13) STEEL-PIPE HANDLE
(14) LEVER
(15) UNIVERSAL SPOUT
(16) FAUCET BOX
(17) FAUCET VALVE
(18) VALVE SPINDLE
(19) PISTON ROD
(20) STOP WATER WEIGHT
(21) FAUCET COVER
(22) UPPER FAUCET
(23) HOSE COUPLING
(24) INNER GLAND BOX
(25) GLAND BOX
(26) LEAKAGE SPOUT
(27) INNER GLAND
(28) GLAND
(29) ROD HEAD
(30) GUIDE PIN



DRIVEN-WELL

The underground water is sucked up through a suction pipe that is driven directly underground.



AVAILABILITY:
Good for every existing dug well and fit for driven wells.

USE:
General home use, sucking, pushing up to a height, fire-preventing and watering.

SPECIFICATION:
Vertical size, 85cm high, steel-pipe handle of 70cm long equipped.

Art. No.	Sort of Well pump	Inside Diameter of Suction Pipe	Suction Capacity Per Hour	More Than Suction Lift	More Than Pushing Lift	Weight
G-700	Driven	1 ¼"	1,100 imp. gallon	30 feet	50 feet	20 kg
G-701	Driven	1 ½"	1,100 imp. gallon	30 feet	50 feet	20 kg
G-702	Dug	1 ¼"	1,100 imp. gallon	30 feet	50 feet	20 kg
G-703	Dug	1 ½"	1,100 imp. gallon	30 feet	50 feet	20 kg

Form 1

Bimonthly Inspection Report of Water Pumps

Location: ______________________

Water pump number: ______________________

Date of inspection: ______________________

Name of inspector: ______________________

1. PHYSICAL CONDITION

Indicate the condition of the following water pump parts.

	GOOD CONDITION	WORN-OUT	BROKEN
Handle:	______	______	______
Plunger Rod:	______	______	______
Pins:	______	______	______
Nuts and bolts:	______	______	______
Pump stand:	______	______	______

2. PERFORMANCE

Indicate if there were a fault in the water pump in the last 2 weeks. Yes ___ No ___

If there were a fault, describe the problem and action, if any, taken to correct it.

____

____

Indicate if there have been complaints about the performance of the water pump. Yes ___ No ___

If there were, describe it.

Form 1 (continued)

3. USAGE

Indicate how many people use this well.

Less than 30	30 to 50	50 to 100	100 to 200	More than 200
________	________	________	________	________

Indicate approximately how many times per day the pump is used.

Less than 30	30 to 50	50 to 100	100 to 200	More than 200
________	________	________	________	________

4. GENERAL OBSERVATIONS

____

____

____

____

____

Pump Performance

To date, the functional performance and acceptance of the Costa Rican-manufactured AID pump has been satisfactory, but there have been casting defects encountered which have caused the replacement of three handles (Battelle drawing No. 2008), two shallow-well caps (Battelle drawing No. 2006), and one plunger cage (Battelle drawing No. 2017). In all cases, these failures have been caused by a lack of quality control at the foundry, which is not possible without laboratory facilities for testing the cast iron. (Table 2 shows maintenance performed to date on all pumps installed in Costa Rica.) The foundry used for the manufacture of the AID pumps in Costa Rica was representative of what might be found in many developing countries, but was not considered by project personnel to be the best in the country. Better foundries were available; however, these foundries were not interested in initial small orders even though the potential for much larger orders existed for the future.

Leather cups have shown considerable wear in AID shallow-well pumps manufactured with metal cylinders and coated with epoxy. The cups appear to wear out for two reasons: first, the walls of the cylinders, even when the epoxy coating is applied, are too rough and, second, the diameter of the metal base of the plunger follower (Battelle drawing No. 2020) where the leather cup sits was made too small (causing the leather cup to catch between the cylinder wall and the base, literally tearing the cup apart). The roughness of the cylinder disappears as the cups hone down the cylinder and corrects itself after several cups have been worn out. If two or three changes of the cups in the early life of the pump are not acceptable, then the cylinder must have a PVC sleeve or be mechanically honed down during its manufacture -- an operation that may not be available in some developing countries. The smallness of the diameter of the plunger's metal base can be easily corrected by manufacturing units that are exact size or slightly on the plus side of specifications (in other words, closer quality control).

PVC cylinders for the AID deep-well pumps have performed exceptionally well, and there have been no leather cups changed in this type of cylinder (which seems to indicate that PVC or honed-down metal cylinders should be used for future pumps). There have been <u>no</u> significant problems with the U.S.-manufactured Dempster or the Japanese-manufactured "Lucky" pumps to date.

Table 2

FIELD TEST PUMP MAINTENANCE - COSTA RICA

Site No.	Location	Type of[1] Pump	Date Installed	April	May	June	July	August	September	October	November	December
1	La Palma	AID-DW	4/22/77	-	-	-	-	-	-	-	-	-
2	San Joaquin	AID-DW	4/22/77	-	-	-	-	-	-	-	-	-
3	El Torito	AID-SW	5/17/77	-	-	-	-	-	-	-	cup and handle replaced	-
4	Hernandez	Lucky	5/18/77	-	-	-	-	-	-	-	-	-
5	Curime	Dempster	5/19/77	-	-	-	-	-	-	-	-	-
6	Pijije	Dempster	5/19/77	-	-	-	-	-	-	-	-	-
7	La Javilla	AID-SW	5/20/77	-	-	handle replaced	-	-	cup and plunger replaced	cotter pins for handle replaced	cup replaced	-
8	Zent #1	AID-SW	5/20/77	-	-	-	-	-	-	handle replaced	-	cup and cap replaced
9	Corina	AID-SW	5/25/77	-	-	-	-	-	-	-	-	-
10	Bristol	AID-SW	5/26/77	-	-	-	-	-	-	-	-	cup replaced
11	La Margarita	Lucky	5/26/77	-	-	-	-	-	-	-	-	-
12	Corazon de Jesus	Dempster	6/1/77	-	-	-	-	-	-	-	-	-
13	Zent #2	AID-SW	6/7/77	-	-	-	-	-	-	-	-	-
14	San Miguel	Dempster	6/15/77	-	-	-	-	-	-	-	-	-
15	Sabalito	Dempster	6/16/77	-	-	-	-	-	-	-	-	-
16	Pueblo Nuevo	AID-SW	6/22/77	-	-	-	-	-	-	cup and cap replaced	-	-
17	San Francisco	Lucky	6/23/77	-	-	-	-	-	-	-	-	-
18	Terciopelo	AID-DW	6/24/77	-	-	-	-	-	-	-	-	-
19	Caimitalito	AID-DW	6/24/77	-	-	-	-	-	-	-	-	-
20	Judas de Chomes	Dempster	8/12/77	-	-	-	-	-	-	-	-	-
21	Limonal	Dempster	9/2/77	-	-	-	-	-	-	-	-	-
22	Zent #3	Lucky	6/7/77	-	-	-	-	-	-	-	-	-
23	Santa Marta	Lucky	7/27/77	-	-	-	-	-	-	-	-	-
24	Tarcolesa	Lucky	8/4/77	-	-	-	-	-	-	-	-	-
25	Mesetas Abajo	Lucky	8/5/77	-	-	-	-	-	-	-	-	-
26	San Juan Grande	AID-DW	8/5/77	-	-	-	-	-	-	-	-	-
27	Sabana Grande	AID-DW	8/10/77	-	-	-	-	-	-	-	-	-
28	Coyolito	AID-DW	8/11/77	-	-	-	-	-	-	-	-	-
29	La Lorena	Dempster	8/12/77	-	-	-	-	-	-	-	-	-
30	Lajas de Canas	AID-DW	8/29/77	-	-	-	-	-	-	-	-	-
31	Indiana Tres	AID-SW	9/8/77	-	-	-	-	-	-	-	-	cup replaced

[1]AID-DW: AID pump for deep well; AID-SW for shallow well; Dempster: Dempster deep-well type pump; Lucky: Japanese-made shallow-well type pump.

In order to determine further the durability of the different test pumps, attempts have been made to correlate the effects of different well depths and the number of people using the wells with the amount of total stress exerted on the test pumps. It is logical to assume that the greater the depth of the well and the greater the number of people using the pump, the greater the pump is stressed in pumping water over a given period of time.

Under normal operating conditions, a pump is never uniformly stressed, that is, the force per unit area varies throughout the structure of the pump. Due to the difficulty in calculating total stress for the entire pump, both theoretical and actual work (in foot-pounds force) was determined on the delivery system of the pump (the amount of work required to lift one pound of water one foot in height). Even though theoretical work and actual work are both directly proportional to stress, theoretical work increased with increasing well depth, while actual on-site work measurements randomly varied with depth (see Table 3).

No correlation could be made between depth and work. These data indicate that friction plays a dramatic role in the amount of work required to pump water. If a water pump is kept in a well-lubricated state, has a smooth cylinder, has a cup that fits snugly but not too tightly inside the cylinder, and has no surfaces that grind against each other, the amount of actual work required to produce water will approach the theoretical work figure. If any of the above conditions are not met (which is almost always the case), the friction factor increases drastically and, as seen in Table 3, a pump operating from a depth of 4.5 meters (Site No. 8) can require 1.2 times as much work as a pump bringing up water from a well 2.2 times as deep (Site No. 2). Measurements will continue to be taken during the remaining monitoring period of this field-testing program to further analyze the relationship between stress on a water pump and the depth of the well.

At present, usage has not been included in the calculations in Table 3, since accurate water consumption per person per day is unknown. However, water meters have been installed on pumps at selected, representative sites in Costa Rica. After a period of four to six months, these meters will be removed and their data recorded. From this, and other daily, short-period data, the total work exerted on each individual pump over a fixed period of time will be examined.

Table 3

WORK EXERTED ON FIELD-TEST PUMPS (COSTA RICA)
AS A FUNCTION OF WELL DEPTH (IN FOOT POUNDS)

Depth (m)	Site No.	Actual Work 1/ ($ft\text{-}lb_f$)	Theoretical Work 2/ ($ft\text{-}lb_f$)	Actual Work/ Theoretical Work	Type of Pump
3.20	10	39	6	6.5	AID-SW
3.25	31	54	6	9.0	AID-SW
3.85	11	23	7	3.3	Lucky
4.10	23	13	7	1.9	Lucky
4.20	13	11	7	1.6	AID-SW
4.50	8	70	8	8.8	AID-SW
4.90	22	30	8	3.8	Lucky
6.10	7	52	10	5.2	AID-SW
6.30	17	58	10	5.8	Lucky
7.61	18	21	12	1.8	AID-DW
9.60	29	39	15	2.6	Dempster
10.00	28	49	16	3.1	AID-DW
10.35	5	38	16	2.4	Dempster
10.50	19	46	17	2.7	AID-DW
10.80	6	38	17	2.2	Dempster
11.55	1	42	18	2.3	AID-DW
11.70	2	58	18	3.2	AID-DW

1/ Calculations for Actual Work. Actual work figures were ascertained, on-site, by measurement with a heavy-duty spring scale of the force required to lift water from each individual well. The force was then multiplied by the length from the plunger rod to the fulcrum point to determine the required work figures.

2/ Calculations for Theoretical Work. When calculations are made to find the amount of theoretical work on a hand pump lifting water, the theoretical force must be found. This is done by first calculating the total number of cubic feet of water from the pump to the water level. The equation used is the following:

$$V = \pi H \left[(R)^2 - (r)^2 \right] + \pi h \left[(r^1)^2 - (r)^2 \right]$$

where

V = Total Volume ($ft.^3$)
R = Radius of drop pipe (ft.)
H = Depth of the well to the water level minus the height of the water inside the pump assembly (ft.)
r = Radius of the plunger rod (ft.)
r^1 = Radius of the pipe inside the pump assembly (ft.)
h = Height of the water inside the pump assembly (ft.)

Table 3 (continued)

When V is determined, it is converted into pounds of water, assuming that one pound of water is equal to 1.603×10^{-2} cubic feet. The total number of pounds of water is then added to the weight of the plunger rod and the plunger assembly. The total amount of force is the result. If this force is multiplied by the length from the plunger rod to the fulcrum point, total theoretical work is ascertained. For example, at Bristol (Site No. 10) in Costa Rica, the variables are as follows:

$$
\begin{aligned}
R &= 0.625/12 \text{ ft.} \\
H &= (10.50 - 1.00) \text{ ft.} \\
r &= 0.250/12 \text{ ft.} \\
r^1 &= 1.50/12 \text{ ft.} \\
h &= 1 \text{ ft.} \\
V &= \pi(9.5)\left[(0.625/12)^2 - (0.250/12)^2\right] + \pi(1)\left[(1.50/12)^2 - (0.250/12)^2\right] \\
V &= 0.06801 + 0.04772 \\
V &= 0.11573 \text{ ft.}^3
\end{aligned}
$$

Therefore, the total number of pounds of water is:

$$
\begin{aligned}
&1 \text{ lb.}/1.603 \times 10^{-2}\text{ft.}^3 = x/0.11573\text{ft.}^3 \\
x &= (1 \text{ lb.})\ (0.11573\text{ft.}^3)/(1.603 \times 10^{-2}\text{ft.}^3) \\
x &= 7.22 \text{ lbs. of water}
\end{aligned}
$$

The total weight of the plunger rod and plunger assembly in this example is 6.75 pounds. The total force is then found to be 13.97 pounds (7.22 plus 6.75). With the distance from the plunger rod to the fulcrum point being 5/12 feet the total theoretical work is 5.82 ft.lb_f (5/12 times 13.97 lb_f).

Water Quality -- Bacteriological and Chemical

Water samples were taken from 13 Costa Rican locations prior to installation of pumps to determine the level of bacteriological contamination in the water being used by rural villagers. (Three of the locations were subsequently dropped as test sites.) All locations, except one, contained Escherichia coli in concentration ranging from 3.6 to 1,100 per 100 ml. sample, as shown in Table 4.

Inasmuch as the presence of E. coli indicates fecal contamination, ideally none should be present. It was not surprising to find this existing condition, however, due to the poorly designed and constructed wells. While the wells were disinfected at the time of their construction, imperfect sealing of the top and seepage of surface water have led to subsequent contamination. Bacterial quantity is subject to considerable variability, and frequent analysis of each

Table 4

SUMMARY OF BACTERIOLOGICAL ANALYSIS, COSTA RICA
(BEFORE PUMP INSTALLATION)

Site No.	Location	Total Coliforms per 100 ml @ 35°C	E. coli per 100 ml @ 44°C
1	La Palma de Abangares	1,100	460.0
2	San Joaquin de Abangares	460	21.0
3	Conjunto IMAS, El Torito, Samara	290	290.0
5	Curime de Nicoya	43	3.6
6	Pijije de Bagaces	150	3.6
7	La Javilla de Canas	93	3.6
16	Pueblo Nuevo de Colorado	1,100	290.0
18	Terciopelo de Nicoya	0	0.0
19	Caimitalito de Nicoya	1,100	120.0
20	Judas de Chomes	210	150.0
--	San Buena Ventuna de Colorado	460	240.0
--	Penas Blancas de Colorado	1,100	1,100.0
--	Nicoya (Barrio San Martin)	210	20.0

Note: All tests performed in accordance with Standard Methods for the Examination of Water and Waste Water, 13th Edition APHA, 1971.

site would be required to provide definitive data; it is noteworthy, on the other hand, that there was only one location free of coliforms. (World Health Organization water quality standards for total coliforms and for E. coli consider 10/100 ml. and 0/100 ml., respectively, as highest permissible levels.)

Water disinfection has been a routine matter in Costa Rica during the installation of pumps, but there has been no laboratory analysis to reveal the extent of assumed contamination in the wells. Because many of the sites in Costa Rica had been disinfected in the past only to result in continued contamination, the sites were tested again after pump installation to measure the effectiveness of pump programs such as this one now being carried out in Costa Rica and Nicaragua.

The bacteriological analyses, shown in Table 5, indicate that all waters involved in the second sampling were polluted to some extent, and some were grossly polluted. The presence of E. coli is taken as an indication of fecal contamination, and thus indicates the possible presence of pathogens associated with the intestinal tract of humans or other mammals. Persistent failure to

Table 5

SUMMARY OF BACTERIOLOGICAL ANALYSIS, COSTA RICA
(AFTER PUMP INSTALLATION)

Site No.	Location	Total Coliforms per 100 ml @ 35°C	E. coli per 100 ml @ 44°C
1	La Palma de Abangares	23	3.6
2	San Joaquin de Abangares	39	3.6
4	Hernandez de Santa Cruz	1,100	150.0
5	Curime de Nicoya	more than 1,100	210.0
6	Pijije de Bagaces	1,100	23.0
7	La Javilla de Canas	more than 1,100	1,100.0
9	Corina	more than 1,100	93.0
10	Bristol	more than 1,100	210.0
11	La Margarita	1,100	53.0
12	Corazon de Jesus de Kutru	1,100	35.0
13	Zent #2 (Sr. Pedro Bustos)	more than 1,100	1,100.0
14	San Miguel de Venado	1,100	460.0
15	Sabalito de Venado	1,100	1,100.0
16	Pueblo Nuevo de Abangares	1,100	43.0
18	Terciopelo de Nicoya	93	93.0
19	Caimitalito de Nicoya	more than 1,100	more than 1,100
--	San Fernando de Santa Cruz	1,100	28.0
--	La Pastora de Quepos	1,100	120.0
--	Santa Domingo de Quepos	290	35.0

Note: All tests performed in accordance with Standard Methods for the Examination of Water and Waste Water, 13th Edition APHA, 1971.

improve the qualities of these waters should, as a general rule, lead to condemnation of the water supply.

It should be noted that Ministry of Health officials in Costa Rica have positively and constructively accepted the results of these water analyses by implementing the suggestions of project personnel to improve their organizational structure. Organizational changes are now under way that will allow trained engineers to look at the complete water system, rather than just the installation of a water pump, and, hopefully, use structures and disinfecting techniques that are actually capable of sealing off all sources of contamination.

Because data were needed on chemical quality of the water represented by the field-test sites, further sampling of the water was carried out soon after pump installation (the results are shown in Table 6). These samples were performed by the Ministry of Health and, with few exceptions, the characteristics of these waters were quite similar.

Table 6

SUMMARY OF CHEMICAL ANALYSES OF WATERS -- COSTA RICA[a]

Site No.	Location	Color	Total Solids	Dissolved Solids	Hardness $CO_3^=$	Hardness Non-$CO_3^=$	Hardness Total	Alkalinity	Fe	Mn	$SO_4^=$	NO_3^-	Observed pH	Saturation pH	Saturation Index[c]
2	San Joaquin de Abangares	5	285.0	256.0	150.0	150.0	150.0	170.0	0.0	0.0	24.0	<1	6.6	11.5	-4.9
3	El Torito de Samara	5	196.0	163.0	112.5	0.0	112.5	120.0	0.0	0.0	38.4	<1	6.5	11.0	-4.5
4	Hernandez de Santa Cruz	5	234.0	231.0	170.0	0.0	170.0	172.5	0.5	0.0	24.0	<1	7.2	11.0	-3.8
5	Curime de Nicoya	5	267.0	223.0	100.0	47.5	147.5	100.0	0.10	0.0	19.2	<1	8.2	11.0	- .25
6	Pijije de Bagaces	5	262.0	231.0	105.0	0.0	105.0	152.5	0.0	0.0	24.0	<1	6.9	11.2	-4.2
7	La Javilla de Canas	5	352.0	316.0	190.0	0.0	190.0	230.0	0.0	0.0	29.0	1	6.7	11.0	-3.3
8	Zent #1	5	166.0	166.0	104.0	16.0	120.0	104.0	0.1	0.0	29.0	1	6.4	11.9	-5.5
9	Corina	5	210.0	172.0	160.0	7.0	167.0	160.0	0.1	0.0	25.0	<1	7.5	11.9	-4.4
10	Bristol	5	230.0	226.0	176.0	4.0	180.0	176.0	0.0	0.1	27.0	<1	6.6	11.9	-5.3
11	La Margarita	7	204.0	197.0	120.0	10.0	130.0	120.0	0.2	0.3	19.2	<1	6.5	11.9	-5.4
13	Zent #2	5	172.0	171.0	69.0	26.0	95.0	69.0	0.1	0.0	19.2	<1	6.4	11.9	-5.5
14	San Miguel de Venado	5	178.0	162.0	97.0	8.0	105.0	97.0	0.0	0.0	0.0	<1	6.7	11.9	-5.2
15	Sabalito de Venado	5	180.0	171.0	49.0	35.0	84.0	49.0	0.0	0.0	4.8	<1	6.5	11.9	-5.4
16	Pueblo Nuevo de Abangares	5	462.0	428.0	380.0	5.0	385.0	380.0	0.0	0.0	43.2	<1	7.1	11.7	-4.6
17	San Francisco de Santa Cruz	5	214.0	196.0	150.0	2.5	152.5	150.0	0.0	0.0	28.0	<1	6.9	11.6	-4.7
18	Terciopelo de Nicoya	5	412.0	411.0	350.0	5.0	355.0	350.0	0.0	0.0	29.0	<1	7.1	11.3	-4.2
19	Caimitalito de Nicoya	5	261.0	252.0	180.0	0.0	180.0	180.0	0.0	0.0	24.0	<1	7.0	11.2	-4.2
22	Zent #3	5	230.0	229.0	146.0	4.0	150.0	146.0	0.1	0.1	25.0	<1	6.6	11.8	-5.2
	WHO Limits:														
	Highest Desirable		500.0		100.0			--	0.10	0.05	200.0	(b)	7.0-8.5		
	Maximum		1,500.0		500.0			--	1.00	0.50	400.0	(b)	6.5-9.2		

a/ All Values mg/l except pH.
b/ Values above 45 mg/l considered potentially harmful, especially to children.
c/ Negative values indicate waters corrosive to metal.

NICARAGUA

Background

Data from 1975 show that 56% of the total population of Nicaragua has relatively easy access to piped water supplies; however, when this figure is broken down into urban and rural areas, it is seen that 100% of the urban population has easy access to this type of water system, while only 14% of the rural population has easy access. Comparative figures for Costa Rica are 72% (total), 100% (urban), and 56% (rural).[1/]

Nicaragua was chosen as a test country because of a rural water supply and hand-pump program loan by AID to that country involving the installation of hand-operated water pumps. The loan provisions included potable water systems that will construct 300-340 wells by the end of 1979, which the AID/Georgia Tech/ICAITI program has complemented by providing technical assistance in pump selection, installation techniques, and pump maintenance, and which has enabled the Ministry of Health in Nicaragua to take advantage of locally manufactured hand pumps that can be produced at a cost lower than commercially available pumps. This local program increases spare parts availability, contributes to a positive balance of trade, and stimulates local employment.

As in Costa Rica, program activities began in Nicaragua in January 1977. A local foundry was chosen to manufacture 20 AID pumps (eleven deep-well and nine shallow-well) which were produced and delivered to a Ministry of Health warehouse for storage and installation in May. Two kinds of locally available pumps were chosen to compare the AID pump with: a Dempster and a Brazilian "Marumby" pump. A pump developed by the International Development Research Centre (IDRC) of Ottawa, Canada, was also used for comparison. Thirty sites, representative of Nicaragua, were approved to receive the test pumps (16 AID pumps and 14 comparative pumps), and all of the sites required extensive preparatory work before pumps could be installed. Pumps were installed by a Ministry of Health installation team, and the wells were disinfected with a chlorine-yielding substance. As in Costa Rica, the sites had chemical and

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1/ World Health Statistics Report, Water and Sanitation, Volume 29, No. 10, published by the World Health Organization, Geneva, 1976.

bacteriological testing prior to installation of test pumps and showed intestinal bacteria, requiring further testing to determine if the contamination is being sealed out by the addition of a closed well and the use of a hand pump for lifting the water.

Field Test Sites

Table 7 shows the sites selected for field testing in Nicaragua. All of the wells were in existence at the beginning of the project, and there was one spring, Site No. 10 (El Naranjo), that was adapted to support a pump. The sites consist of 16 shallow wells and 14 deep wells equipped with 16 AID pumps and 14 comparative pumps. Usage is quite high for the sites, averaging 170 persons, and all wells have required improving site work of some kind (well deepening, lining applied to the well, slab and drainage concrete work performed, and cleaning and disinfecting of the well). Seven originally selected sites posed problems that neccessitated a search for substitute wells. The problems included the striking of hard rock during excavation, wells caving in, water sources polluted beyond the ability to correct quickly, and villagers deciding that they would prefer an electric pump and storage tank to a hand-operated water pump (even if the villagers had to pay for the electric pump and storage tank). The general areas of site concentration are in the northern section of Nicaragua in the vicinity of Condega, Esteli, and Matagalpa (see Maps 2 and 3).

It was the original intent of this project to use existing wells with pumps that were inoperable or in a state of disrepair and to merely replace the broken pumps with the test pumps. However, this approach was impractical in Nicaragua because there were few existing hand-pump installations and it was, therefore, necessary to deepen 24 wells, provide linings for 12 wells, construct slabs for 30 well structures, and disinfect all 30 wells to complete installation of the pumps. The construction improvements were provided and supervised by PLANSAR, an impressive unit of the Ministry of Health.

Manufacture of AID Pumps

Manufacturing Costs. In manufacturing the AID pumps in Nicaragua, a somewhat surprising situation was encountered -- foundries were plentiful, but pattern makers, a very necessary requirement for local production, were almost nonexistent. A foundry was located that appeared to have the resources, including

Table 7

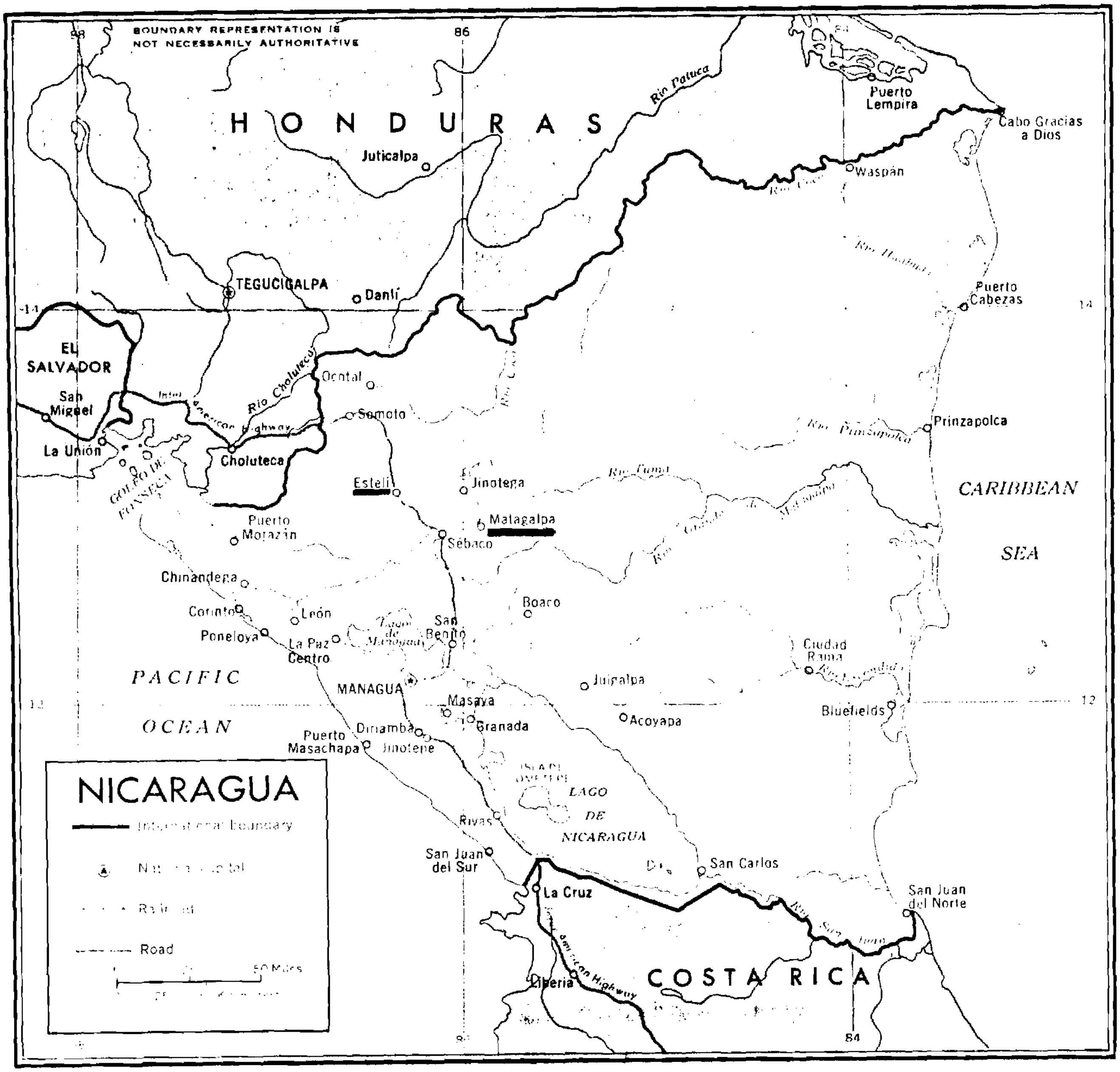
SELECTED SITES FOR AID PUMP FIELD TESTS IN NICARAGUA

Site No.	Location	Well Situation	Well Type	Classification by Depth	Depth (m)	Estimated Usage - No. People	Type of Original Pump	Condition of Original Pump	Has Water Meter	Type of Pump Installed	Date Installed
1	La Garita (Schoolhouse)	Existing	Dug	Deep	8.98	150	None	--		Dempster	4/27/77
2	Las Lajitas	Existing	Dug	Shallow	5.85	160	None	--	X	Marumby	5/12/77
3	La Lamilla	Existing	Dug	Deep	15.38	100	None	--		Dempster	5/12/77
4	San Antonio	Existing	Dug	Deep	10.42	100	None	--	X	Dempster	5/13/77
5	Las Mesas	Existing	Dug	Shallow	5.70	150	None	--		Marumby	5/16/77
6	Las Mangas	Existing	Dug	Deep	14.66	400	None	--		AID-DW	6/16/77
7	Llane Grande	Existing	Dug	Shallow	3.97	150	None	--		CAN-SW	5/28/77
8	San Diego	Existing	Dug	Shallow	5.03	100	None	--		Marumby	5/28/77
9	Mechapa	Existing	Dug	Deep	18.75	190	None	--		Dempster	6/4/77
10	El Naranjo	Existing	Spring	Shallow	3.12	210	None	--		AID-SW	5/28/77
11	Isidrillo	Existing	Dug	Deep	26.10	360	None	--		Dempster	6/11/77
12	La Concepcion	Existing	Dug	Shallow	2.85	280	None	--		AID-SW	6/8/77
13	El Rodeo	Existing	Dug	Deep	17.05	75	None	--		Dempster	6/17/77
14	Los Calpules (Stream)	Existing	Dug	Shallow	3.75	150	None	--		AID-SW	6/22/77
15	Los Calpules (Schoolhouse)	Existing	Dug	Deep	9.45	150	None	--		Dempster	6/22/77
16	Paso Hondo	Existing	Dug	Shallow	7.55	75	None	--		Dempster	6/23/77
17	Quebrada Arriba	Existing	Dug	Shallow	4.73	150	None	--		Marumby	7/21/77
18	Las Lajas	Existing	Dug	Shallow	6.65	90	None	--		AID-SW	7/26/77
19	Los Hatillos (Plaza)	Existing	Dug	Deep	17.19	100	None	--		AID-DW	7/26/77
20	Los Hatillos	Existing	Dug	Deep	17.25	100	None	--		AID-DW	7/27/77
21	Musuli	Existing	Dug	Deep	10.16	50	Dempster	Broken		AID-DW	7/27/77
22	Los Rincones	Existing	Dug	Deep	9.46	150	Dempster	Broken		AID-DW	7/28/77
23	Santa Rosa	Existing	Dug	Deep	17.60	656	Dempster	Broken	X	AID-DW	7/29/77
24	El Jocote	Existing	Dug	Deep	15.00	150	None	--		AID-DW	7/28/77
25	Mechapa - La Conception	Existing	Dug	Shallow	2.95	54	None	--		AID-SW	7/29/77
26	Licoroy	Existing	Dug	Shallow	5.00	50	None	--		AID-SW	7/30/77
27	Tomabu	Existing	Dug	Shallow	2.50	250	None	--		AID-SW	7/29/77
28	El Espinal #1	Existing	Dug	Shallow	3.50	360	None	--	X	AID-SW	7/30/77
29	El Espinal #2	Existing	Dug	Shallow	5.95	300	None	--	X	AID-SW	7/30/77
30	Sabana Grande	Existing	Dug	Shallow	2.80	75	None	--		Marumby	8/9/77

Note: AID-DW: AID pump for deep well; AID-SW: AID pump for shallow well; Dempster: Dempster deep-well type pump; Marumby: Brazilian shallow-well type; CAN-SW: Canadian pump for shallow well.

Map 2

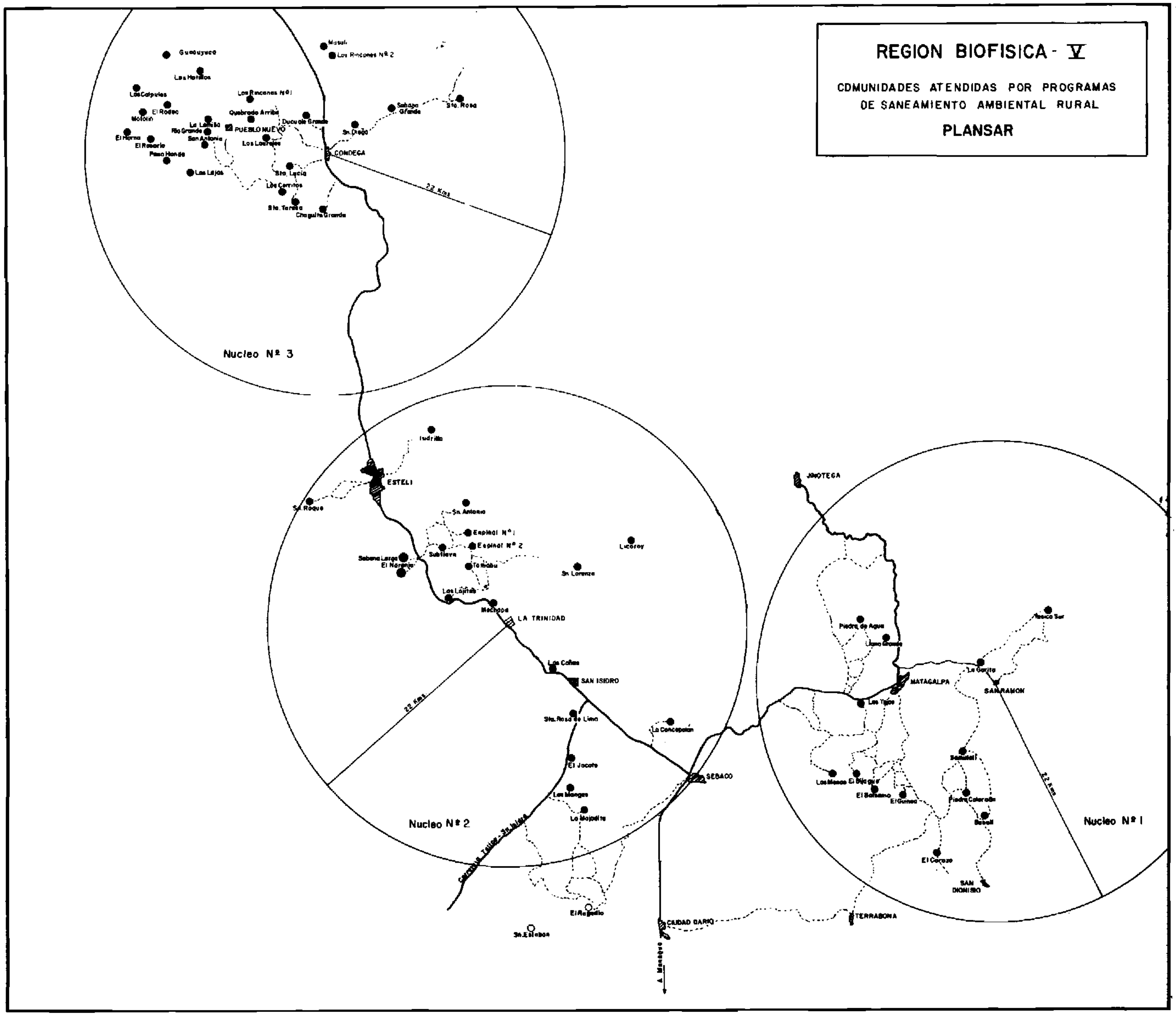
NICARAGUAN TEST SITE AREAS



Sites in Nicaragua are concentrated in the northern part of the country, near Condega (not shown on this map), Esteli, and Matagalpa.

Map 3

NICARAGUAN TEST SITE AREAS



pattern makers, to manufacture a quality AID pump, and a contract was signed on January 22, 1977, between Georgia Tech and Complejo Metalurgico Especializado, S.A. (Cometales) for the manufacture of eleven deep-well pumps and nine shallow-well pumps. The prices of the pumps, for an order of 20, were as follows:

Shallow-well	$	69 (each)
Deep-well		75 (each)
Patterns		1,000 (one-time charge only)

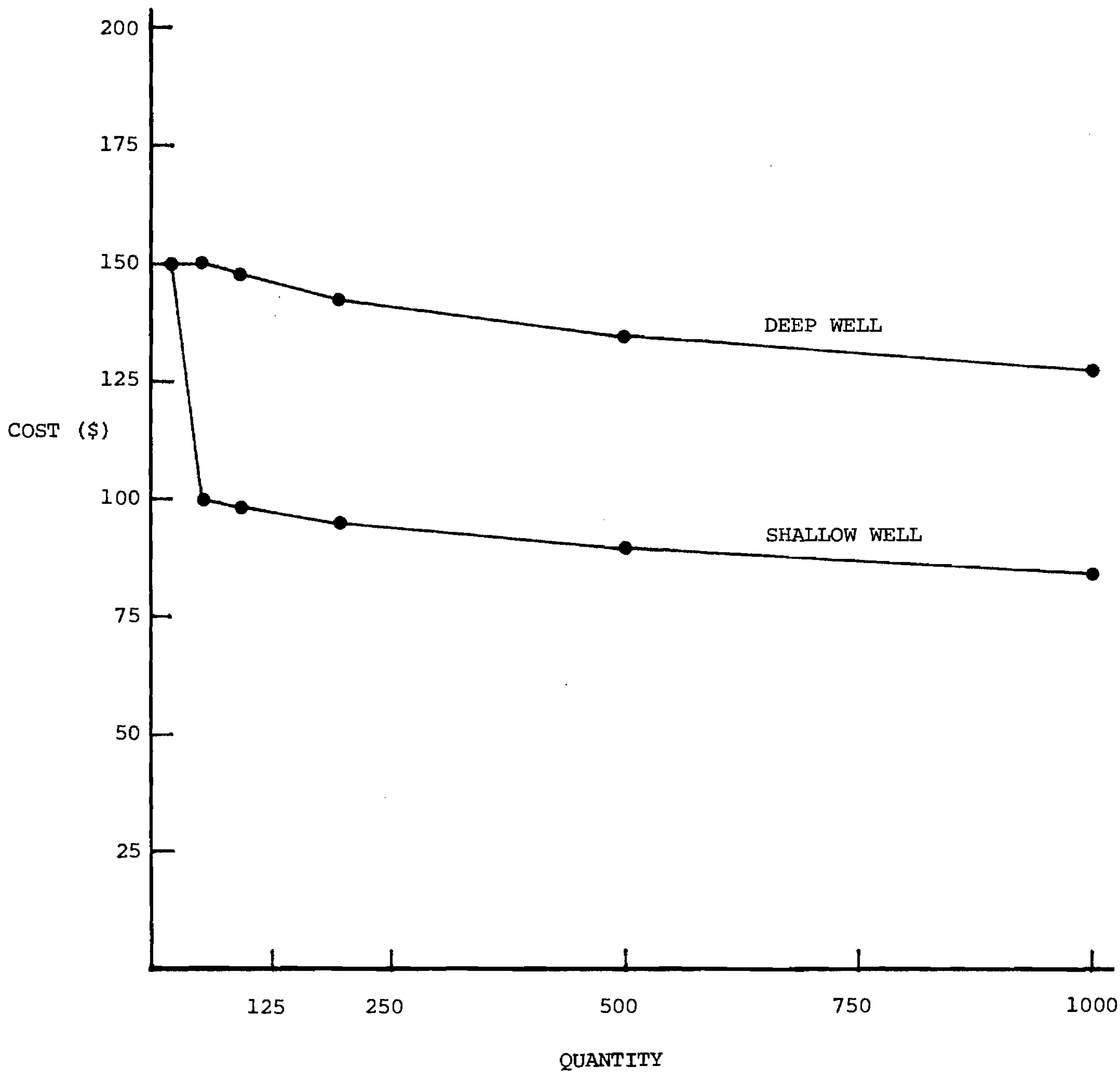
Based on the manufacturer's experiences with the first production run of the pumps, the following prices have been formally quoted for future orders, and are presented graphically in Figure 7.

Quantity	Shallow-Well ($ Price/Unit)	Deep-Well ($ Price/Unit)
20	150	150
50	100	150
100	98	147
200	95	142
500	90	135
1000	85	127

As was the case in Costa Rica, an order for only 20 pumps offered no significant economies of scale, and start-up costs were higher than originally expected because the manufacturer was totally unfamiliar with the working components of water pumps. The manufacturer encountered many unforeseen problems that increased his costs, such as the inability to cast the deep-well pump cap as specified and to obtain correctly sized PVC (3-inch inside diameter) for the deep-well cylinder, as well as a severe drought that struck Nicaragua which restricted the supply of hydroelectric power to the point that the manufacturer was allowed only four hours per day of electricity to run his plant. As a result of the manufacturer's experiences with the first production run of the AID pump, much higher price quotes have been submitted to the Ministry of Health for future orders. It is felt that the increased prices are over-inflated and, considering the weight of the AID pump (approximately 75 lbs.) versus a general foundry pricing guideline for Central America of between one and two dollars per pound (depending on complexity of the product), a more realistic pricing structure would allow the AID pump (both shallow-well and deep-well) to be manufactured and sold for less than $100. This opinion has

Figure 7

COST BY QUANTITY TO PRODUCE
AID PUMPS IN NICARAGUA



been passed along to the manufacturer, and a reconsideration of the manufacturer's prices has been requested.

Manufacturing Specifications. AID pumps in Nicaragua were also manufactured according to the approved drawings contained in the Appendix to this report and with the following additional instructions:

1. The plunger rod was made from 1/2-inch diameter rod, rather than 7/16-inch stock. The pump rod nut, the rod end, and the plunger assembly also were changed to accommodate the 1/2-inch plunger rod.
2. The handle pivot pins were hardened to 40 R_C, and steel bushings (60-64 R_C) were inserted in the pump handle holes.
3. For the shallow-well pump, the 3-inch support pipe was internally coated with epoxy for a smoother surfaced cylinder finish. Option A (drawing No. 2001), using the bolted pump cap, was chosen in preference to a pin-mounted pump cap.
4. For the deep-well pump (drawing No. 2002), Option A was chosen, using the bolted pump cap in preference to a pin-mounted pump cap.

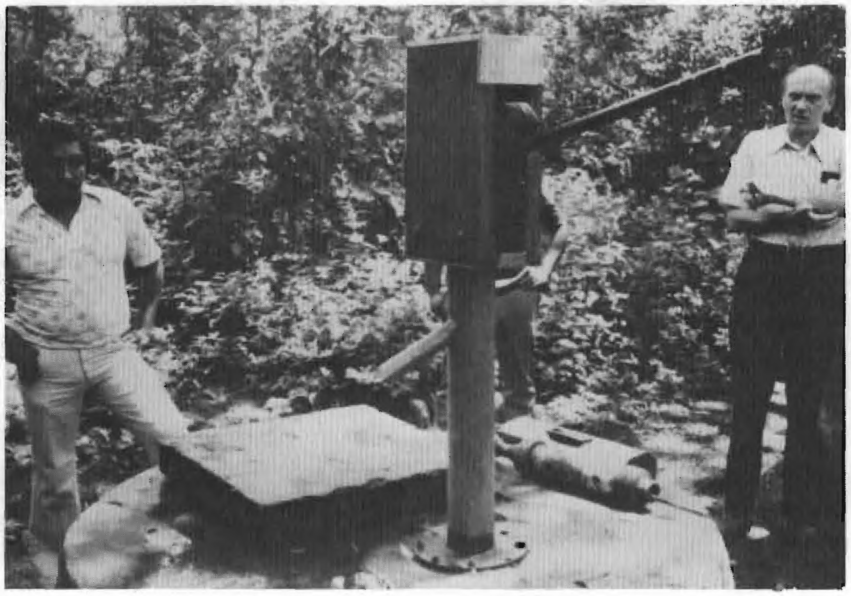
The AID pump manufacturer in Nicaragua had a complete, integrated foundry and machine shop with trained metallurgists in the day-to-day management of the company. The manufacturer also possessed, and used, laboratory analysis facilities for the casting process, a quality control ingredient that is not normally expected to be found in developing countries. While it appears that the AID pump is adaptable to local manufacture in Nicaragua, the requirement of available casting facilities will most likely restrict the use of the pump in some developing countries.

Comparative Pumps

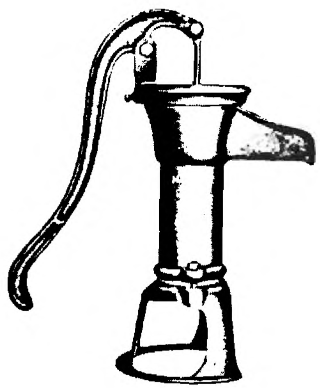
Two pumps were chosen for comparison with the AID pump that were locally available to the people of Nicaragua. These pumps were the Dempster (for shallow or deep wells) and a Brazilian "Marumby" pump (for shallow wells only). A pump developed by IDRC (for shallow or deep wells) was also used for comparison purposes (see Figure 8). The Dempster is designed for heavy-duty use in both shallow and deep wells, has a brass-lined cylinder, is made of cast iron, and has a very good worldwide reputation, as pointed out earlier. The Brazilian pump (see Figure 9) uses a 1 1/4-inch drop pipe (as do the Dempster

Figure 8

THE IDRC PUMP



The above photo is of the IDRC-developed pump that was installed at Llano Grande (Site No.7), in Nicaragua. The pump is made of indigenous materials (wood, galvanized iron pipe, and PVC pipe) and represents a design that simplifies hand pumps mechanically by substituting plastic pipe for traditional steel and cast iron. The casing is three-inch PVC pipe that serves as the drop pipe and the cylinder housing the piston assembly (this allows the piston and check valve to be brought up for inspection by pulling up the plunger rod without disassembling the drop pipe). Both piston and check valve are made of the same interchangeable components: perforated plastic discs with flapper valves covering the holes. The pump handle is made of standard galvanized iron pipe and the pivot points use oil-impregnated wooden bearings.



BOMBA SIMPLES

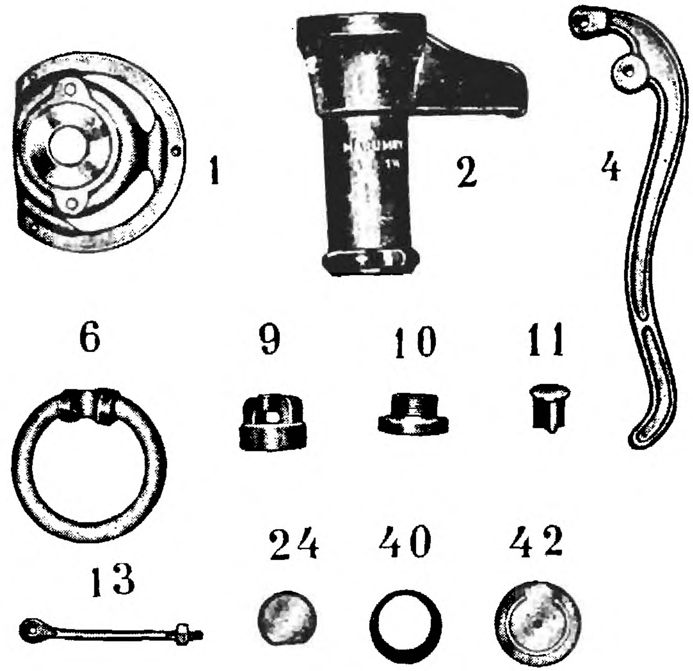
(BICA DE JARRO)

Tipo BJ

Para cano de 1¼" com pistão de ferro Cr$..

ESPECIFICAÇÕES:

Sucção cano de (Suction tube)	1¼"	
Altura do corpo (Height of body)	280	mm.
Diâmetro interno do cilindro (ID of cylinder)	80	mm.
Rendimentos em 55 movimentos do pistão por minuto (Flowrate/min.)	22	L.
Sucção até (Suction depth)	7	m.
Pêso líquido (Weight of liquid)	13	kg.



Peca n.º 1 - Prato (Plate)
2 - Corpo (Body)
4 - Alavanca (Handle)
6 - Anel suporte alavanca (Support ring)
9 - Corpo do pistão (Piston body)
10 - Porca do pistão (Piston nut)
11 - Válvula do pistão (Piston valve)
13 - Haste do pistão (Piston rod)
24 - Pêso da válvula (Valve weight)
40 - Manga de couro (Leather sleeve)
42 - Válvula de couro p/ prato (Leather valve for plate)

Figure 9

MARUMBY (BRAZILIAN) PUMP

and AID pumps) and has a cylinder slightly over three inches (3.1") of smooth cast iron. The pump developed by IDRC uses a 3-inch diameter PVC drop pipe that is unique in that it also serves as the cylinder for the piston assembly (which can be inserted into or withdrawn from the cylinder while the cylinder and drop pipe are attached to the pump that is secured to the well's upper structure).

The Dempster pump costs approximately $257 in Central America, the Brazilian "Marumby" approximately $45, and the IDRC pump about $70 (this estimated $70 cost is for comparison only and can vary widely, depending on the materials and the pricing systems used by the fabricating shop). It is interesting, at this point, to recap all pumps included in the field testing of the AID pump, noting, as explained earlier, that price estimates for the manufacture of the AID pump vary greatly from country to country as well as from manufacturer to manufacturer within the same country.

		Costa Rica	Nicaragua
1.	AID Shallow-Well (for shallow wells only)	$ 98	$ 69
2.	Japanese "Lucky" (for shallow wells only)	63	--
3.	Brazilian "Marumby" (for shallow wells only)	--	45
4.	AID Deep-Well (for deep and shallow wells)	128	75
5.	Dempster (for deep and shallow wells)	257	257
6.	IDRC PVC Cylinder (for deep and shallow wells)	--	70

Another approach to analyzing the relative costs of the field-test pumps is to consider the total estimated cost of installing each pump complete with drop pipe (average price @ $.70 per foot), plunger rod (average price @ $.71 per foot), drop pipe connectors (average price @ $.91 each), and plunger rod connectors (average price @ $1.06 each) at various depths. The Brazilian "Marumby" shallow-well pump extends to $63 for a 25-foot well. The Japanese "Lucky" shallow-well pump, when installed in a 25-foot well, costs $81. The AID shallow-well pump, installed at 25 feet, costs $87 in Nicaragua and $116 in Costa Rica. The Dempster pump for shallow or deep wells is a very good pump but is very expensive, also. The IDRC pump for shallow or deep wells, is competitive in cost with the AID pumps used for deep wells (or shallow well, if so desired). However, the cost data on the IDRC pump for this report represents only one pump and does not give enough information for reliable conclusions.

	25 ft.	50 ft.	75 ft.	100 ft.	150 ft.	200 ft.	250 ft.
AID Shallow Well (C.R.)*	$116	$ --	$ --	$ --	$ --	$ --	$ --
AID Shallow Well (Nic.)*	87	--	--	--	--	--	--
Japanese "Lucky"*	81	--	--	--	--	--	--
Brazilian "Marumby"*	63	--	--	--	--	--	--
AID Deep Well (C.R.)	135	172	210	251	324	398	474
AID Deep Well (Nic.)	106	143	181	222	295	369	445
Dempster	294	331	369	410	483	557	633
IDRC (three-inch PVC cylinder)**	123	167	212	254	355	452	537

* Cannot be used for depths of more than 25 ft.

**PVC priced @ $1.20 per foot.

Monitoring System

In Costa Rica, designated, responsible individuals in each test community have been provided with simple, printed report forms designed to provide information covering community usage, pump physical condition, and functioning problems, if any. These forms are filled out every 15 days and mailed to an AID engineer in San Jose for analysis, who then reproduces them and turns the copies over to Ministry of Health representatives. If any of the returned forms indicate that repairs are necessary, a maintenance team is dispatched to correct the problems.

The monitoring system in Nicaragua is similar to that in Costa Rica, except that all pumps are inspected every 15 days by Ministry of Health engineers who are permanently stationed in the field and are responsible for the completion of the report forms as well as initiating any necessary repairs. Information included in the report forms is reviewed periodically by ICAITI and recorded on pump performance charts. All Nicaraguan test sites have been inspected at one month intervals by Georgia Tech and/or ICAITI, also.

Pump Performance

To date, the Nicaraguan-manufactured AID pumps have been very well received by the people installing, operating, and maintaining them. Because of confidence that the Ministry of Health has in the pumps, an additional 100 have been ordered by the Ministry from the manufacturer for future installation.

Two major problems with the AID pump (see Table 8) became apparent when installation of the pumps began. The most critical problem was that the deep-well pump cap's (Battelle drawing No. 2027) weakest point was where maximum stress was being applied by the handle fulcrum upon the pivot arm of the cap, causing the pivot arm to break off from the cap. This problem caused very close to a 100% pump failure and was partly the fault of the design and partly the fault of the manufacturer. Because of the indented contour of the top plate of the pump body (see Battelle drawing No. 2007), it is not possible to cast the pump body as specified by the drawings (the patterns for the pump cannot be removed from the molding sand without destroying the mold). Therefore, the manufacturer eliminated the indented contour of the top plate of the pump and then did not have enough clearance between the pivot arm of the cap and the top of the pump body. In order to obtain a better fit between the pump cap and the pump body, the manufacturer milled away a fillet on the pivot arm, thereby leaving a notch and a weak link at the point of maximum stress. To alleviate the entire problem, the pump cap has been redesigned by lifting the pivot arm up and away from the pump body and positioning it so that it does not absorb so much of the stress caused by the downward force of the pump handle (the fulcrum handle, naturally, had to be shortened). (See Figures 10 and 11.) The redesigned cap was put into production at the manufacturer's foundry, installed on the pumps in the field, and has presented no additional problems.

The second major problem encountered with the AID pump in Nicaragua evolved when the manufacturer could not find 3-inch (inside diameter) PVC pipe for the deep-well cylinders. As a result, the manufacturer used 3-inch (outside diameter) PVC pipe and expanded it, by heating, to a 3-inch inside diameter. Quality control for such an approach was most difficult, and the results were unacceptable. While several of these PVC cylinders were installed in the field, it was decided that metal cylinders, coated internally with epoxy, would have to be used until the correct size PVC could be made available locally or imported from another country.

Excessive wearing of leather cups has also presented problems for the AID pump in Nicaragua. Battelle drawing No. 2019 specifies a 3-inch diameter leather cup for a 3-inch cylinder, which would be satisfactory if leather did not expand when wet. To allow for expansion, the dry cups should have been made approximately 1/16-inch diameter undersized. A replacement order for the

Table 8

FIELD TEST PUMP MAINTENANCE - NICARAGUA

Site No.	Location	Type of Pump	Date Installed	April	May	June	July	August	September	October	November	December
1	La Garita	Dempster	4/27/77	-	-	-	-	-	-	-	-	-
2	Las Lajitas	Marumby	5/12/77	-	-	-	-	-	-	-	-	base gasket replaced
3	La Lamilla	Dempster	5/12/77	-	-	-	-	-	-	-	-	-
4	San Antonio	Dempster	5/13/77	-	-	-	-	-	-	-	-	-
5	Las Mesas	Marumby	5/16/77	-	-	-	-	-	-	-	-	-
6	Las Mangas	AID-DW	6/16/77	-	-	-	-	cap replaced	-	-	-	-
7	Llano Grande	CAN-SW	5/28/77	-	-	-	-	-	foot valve replaced	-	-	-
8	San Diego	Marumby	5/28/77	-	-	-	-	-	-	-	-	cap is cracked and needs replacing
9	Mechapa	Dempster	6/4/77	-	-	-	-	-	-	-	-	-
10	El Naranjo	AID-SW	5/28/77	-	-	-	-	-	-	-	-	-
11	Isidrillo	Dempster	6/11/77	-	-	-	plunger rod replaced	-	-	-	-	-
12	La Concepcion	AID-SW	6/8/77	-	-	-	-	-	-	-	-	-
13	El Rodeo	Dempster	6/17/77	-	-	-	-	-	-	-	-	-
14	Los Calpules	AID-SW	7/22/77	-	-	-	-	cup replaced	cup and cylinder replaced	-	-	cup and cap replaced
15	Los Calpules	Dempster	6/22/77	-	-	-	-	-	-	-	-	-
16	Paso Hondo	Dempster	6/23/77	-	-	-	-	-	-	-	-	-
17	Quebrada Arriba	Marumby	7/21/77	-	-	-	-	-	-	-	-	cap is cracked and needs replacing
18	Las Lajas	AID-SW	7/26/77	-	-	-	-	-	cup replaced	-	-	-
19	Los Hatillos	AID-DW	7/26/77	-	-	-	-	-	cap replaced	-	cylinder replaced	-
20	Los Hatillos	AID-DW	7/27/77	-	-	-	-	-	-	cap replaced	-	-
21	Musuli	AID-DW	7/27/77	-	-	-	-	-	-	-	-	-
22	Los Rincones	AID-DW	7/28/77	-	-	-	-	-	cylinder replaced	-	-	cap replaced
23	Santa Rosa	AID-DW	7/29/77	-	-	-	-	-	cap and cylinder replaced	-	-	cup replaced
24	El Jocote	AID-DW	7/28/77	-	-	-	-	-	-	-	-	-
25	Mechapa - La Concepcion	AID-SW	7/29/77	-	-	-	-	-	-	-	-	-
26	Licoroy	AID-SW	7/30/77	-	-	-	-	-	-	handle replaced	-	-
27	Tomabu	AID-SW	7/29/77	-	-	-	-	-	-	-	cap replaced	-
28	El Espinal	AID SW	7/30/77	-	-	-	-	-	-	-	-	cup replaced
29	El Espinal	AID-SW	7/30/77	-	-	-	-	-	-	-	-	-
30	Sabana Grande	Marumby	8/9/77	-	-	-	-	-	-	-	-	cap replaced

Figure 10

MODIFIED DEEP-WELL PUMP CAP
IN NICARAGUA

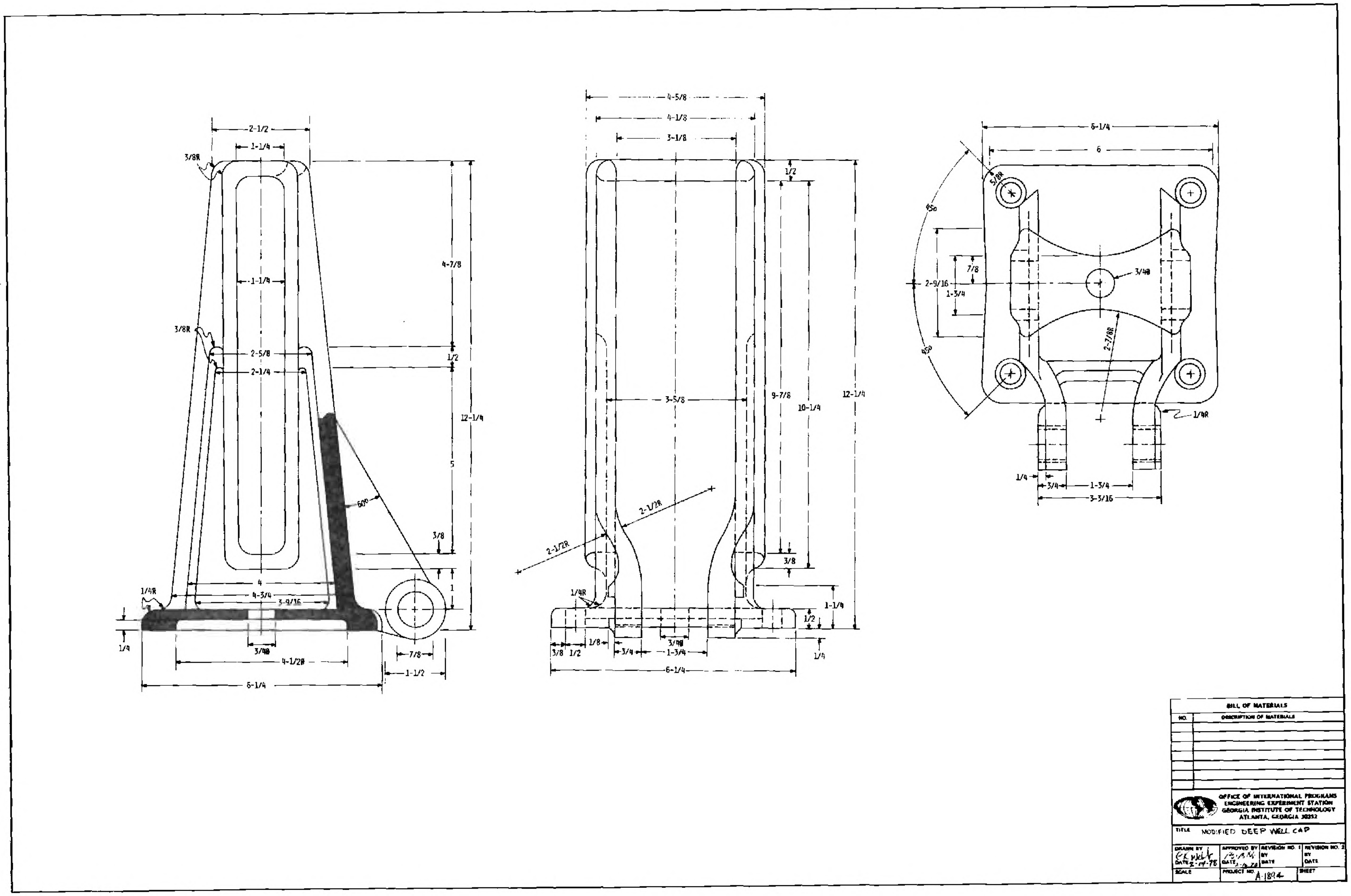
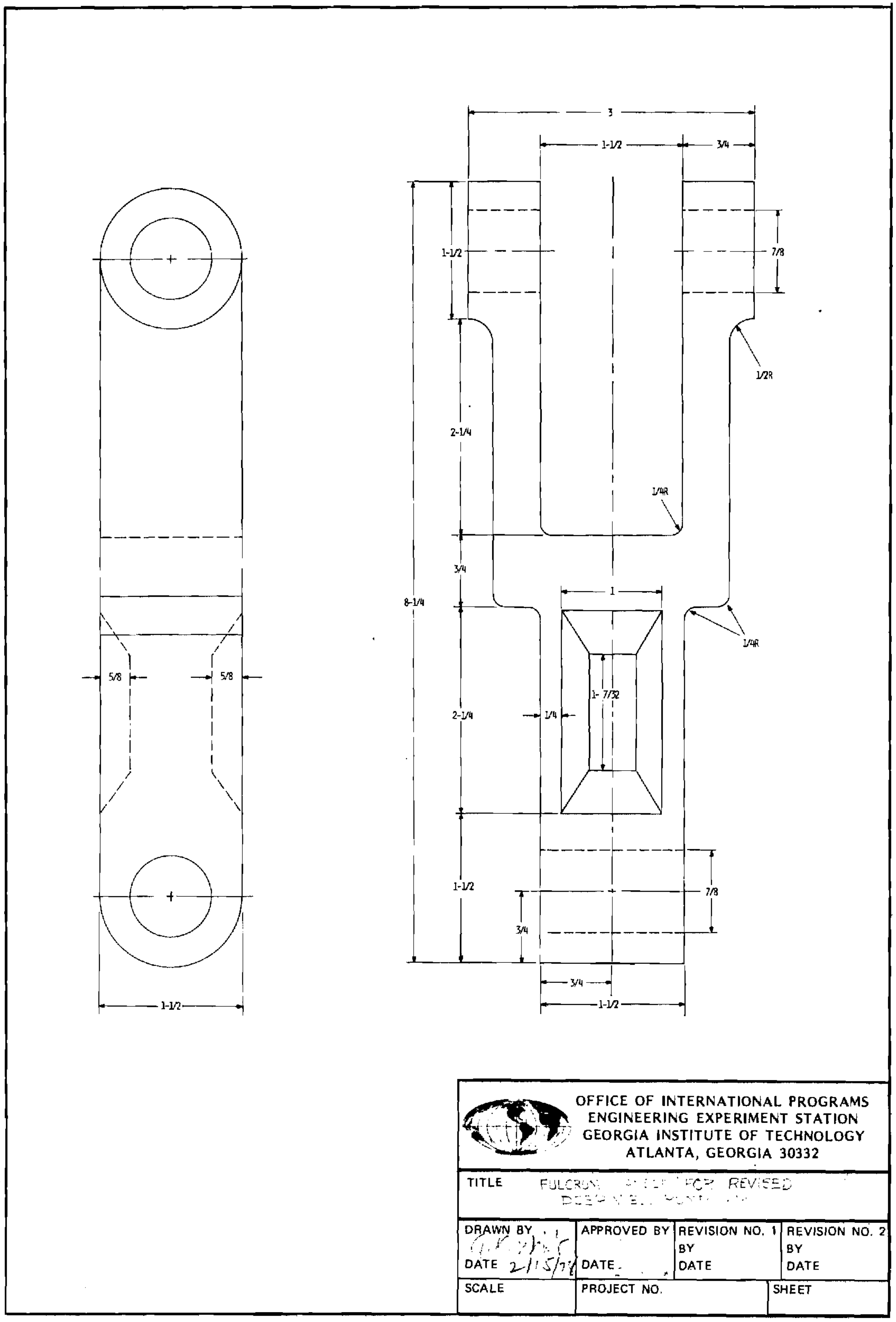


Figure 11

FULCRUM HANDLE FOR MODIFIED DEEP-WELL
PUMP CAP IN NICARAGUA



original oversized cups was filled by the pump manufacturer, and the wearing of these new cups has been considerably less due to the use of a blanking tool that improves the quality controls of the manufacturer. The blanking tool has proven to be very beneficial and is being modified to resemble a method suggested by Dr. Eugene McJunkin, in a recent publication:

> For "mass production," wooden forms can be used. To make the forms, use wooden boards about 3/4-inch (approx. 19mm) in thickness, having holes of the same diameter as the pump cylinders, and nailed to a stiff backboard. Cylindrical blocks, 3/8-inch (approx. 9.54mm) less in diameter, are bolted concentrically within the circular openings. The bolts should be long enough so that . . . wet and pliable leather, laid over the holes, can be drawn down by the bolts and blocks, forcing the leathers into position . . . let dry, remove and trim the wrinkled edge with a sharp knife (including the center hole), soak for 12 hours in an edible oil (preferably neat's-foot), wax, and lightly apply graphite grease to the wearing surface.[1/]

The Brazilian "Marumby" pump is beginning to have problems. The weakest point of the pump appears to be where the handle and the pump cap are connected. In three of the five pumps being tested, the pump cap has had to be, or needs to be, replaced due to breakage at this point. Spare parts are also difficult to find for this pump, and the local distributor does not carry a large inventory of extra pumps for replacement purposes -- a factor that enhances the argument for locally manufacturing pumps so that spare parts can be made readily available.

The Dempster pumps in Nicaragua, as in Costa Rica, have had no major problems. The IDRC pump has performed relatively well but has had some difficulty with its foot valve sticking in the open position (allowing the pump to lose its prime).

Attempts also have been made in Nicaragua to correlate the effects of different well depths and the number of people using the wells with the amount of total stress exerted on the pumps. Because of the tremendous role friction obviously plays on the performance of the pumps (all types) and the many varying factors that change the amount of friction on an almost daily basis, no correlation could be made between the durability of the pump and the depth of

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1/ F. Eugene McJunkin, Handpumps for Use in Drinking Water Supplies in Developing Countries, (The Hague, the Netherlands: International Reference Center for Community Water Supply, 1977), p. 196.

the wells (see Table 9). Water meters also have been installed at representative sites in Nicaragua to study the effects of usage of the pumps and their respective maintenance requirements.

Table 9

WORK EXERTED ON FIELD-TEST PUMPS (NICARAGUA)
AS A FUNCTION OF WELL DEPTH (IN FOOT POUNDS)

Depth (m)	Site No.	Actual Work ($ft\text{-}lb_f$)	Theoretical Work ($ft\text{-}lb_f$)	Actual Work/ Theoretical Work	Type of Pump
3.50	28	8	6	1.3	AID-SW
3.75	14	12	7	1.7	AID-SW
5.85	2	10	10	1.0	Marumby
5.95	29	24	10	2.4	AID-SW
9.46	22	64	15	4.3	AID-DW
10.16	21	34	16	2.1	AID-DW
10.42	4	77	17	4.5	Dempster
17.60	23	38	27	1.4	AID-DW
18.75	9	150	29	5.2	Dempster

Note: While the above data have been gathered from only nine of the thirty sites in Nicaragua, it is felt that the measurements are representative of all sites. In the next several months all sites will be examined and analyzed, however.

Water Quality -- Bacteriological and Chemical

The results of chemical analyses of 19 potential sites prior to pump installation are given in Table 10. For comparison, the limits established by the World Health Organization are also included.[1/] An examination of the bacteriological data (Table 11) shows that all sites were significantly contaminated with common intestinal bacteria prior to pump installation. Salmonella was initially reported at Los Laureles, and this point was rechecked and found to be negative.

1/ International Standards for Drinking Water, Third Edition, published by the World Health Organization, Geneva, 1971.

Table 10

SUMMARY OF WATER CHEMICAL ANALYSES[a] -- NICARAGUA
(BEFORE PUMP INSTALLATION)

Site No.	Location	pH	Hardness as $CaCO_3$	Alka-linity as HCO_3^-	Total Solids	Fe	Mn	Ca	NO_3^-	F	Cl	$SO_4^=$
1	La Garita	7.0	350	26	218	0.07	0.05	70.0	3.76	0.30	22.5	2.0
2	Las Lajitas	7.5	200	190	225	0.02	0.40	50.0	4.43	0.35	5.0	2.0
4	San Antonio	7.9	240	270	404	0.01	0.00	68.0	2.65	0.50	19.5	11.0
6	Las Mangas	6.4	100	100	38	0.02	0.00	20.0	2.21	0.50	15.0	2.0
7	Llano Grande	6.4	200	120	161	0.07	0.00	30.0	9.96	0.70	12.5	3.0
8	San Diego	7.6	260	290	398	0.10	0.00	56.1	2.35	0.40	25.0	15.0
9	Mechapa	7.7	325	30	330	0.06	0.00	80.0	13.10	0.40	12.5	8.0
10	El Naranjo	6.9	400	420	426	0.05	0.00	100.1	3.54	0.70	15.0	3.0
11	Isidrillo	7.6	400	180	100	0.07	0.00	90.0	306.50	0.35	62.5	10.0
14	Los Calpules (Stream)	7.9	290	330	394	0.01	0.10	80.0	0.00	0.55	10.0	2.0
15	Los Calpules (School)	7.9	210	200	237	0.01	0.00	50.0	5.10	0.60	12.5	4.0
17	Quebrada Arriba	7.5	180	280	360	0.10	0.28	44.1	1.76	0.20	15.0	8.3
22	Los Rincones	8.1	70	445	608	0.01	0.00	20.0	16.60	0.25	20.0	20.0
	Los Rastrojos	7.6	840	260	1,600	0.27	0.58	292.0	0.66	1.62	20.0	67.5
	Santa Teresa	8.1	240	265	383	0.01	0.00	62.0	9.52	0.35	15.5	11.0
	Los Laureles	7.7	250	265	340	0.01	0.00	64.0	6.42	0.60	15.0	6.0
	Rio Grande	8.0	190	250	336	0.25	0.28	52.1	4.80	0.20	25.0	10.5
	Motolin	8.2	240	250	298	0.05	0.00	62.0	22.40	0.65	14.0	4.0
WHO limits:												
	Highest desirable	7.0-8.5	100	--	500	0.10	0.05	75.0	(b)	(c)	200.0	200.0
	Maximum permissible	6.5-9.2	500	--	1,500	1.00	0.50	200.0	(b)	(c)	600.0	400.0

(a) All values mg/l except pH.
(b) Values above 45 mg/l considered potentially harmful, especially to children.
(c) Limit depends on daily air temperature. Upper limits range from 0.8 to 1.7 mg/l.

Table 11

SUMMARY OF BACTERIOLOGICAL ANALYSIS -- NICARAGUA
(BEFORE PUMP INSTALLATION)

Site No.	Location	Coliforms per 100 ml	Salmonella Presence	Shigella Presence	Comments
1	La Garita	2.4	Negative	Negative	Positive Enterobacter
2	Las Lajitas	150.0	Negative	Negative	Positive Enterobacter
3	La Lamilla	350.0	Negative	Negative	Positive Escherichia coli
4	San Antonio	120.0	Negative	Negative	Positive Escherichia coli
7	Llano Grande	430.0	Negative	Negative	Positive Enterobacter and Citrobacter
9	Mechapa	1,100.0	Negative	Negative	Positive Proteus and Citrobacter
10	El Naranjo	1,100.0	Negative	Negative	Positive Enterobacter
11	Isidrillo	1,100.0	Negative	Negative	None
13	El Rodeo	540.0	Negative	Negative	Positive Escherichia coli
14	Los Calpules (stream)	23.0	Negative	Negative	Positive Escherichia coli
15	Los Calpules (school)	920.0	Negative	Negative	None
22	Los Rincones	54.0	Negative	Negative	Positive Pseudomonas
--	Rio Abajo (Santa Teresa)	24.0	Negative	Negative	Positive Enterobacter
--	*Rio Abajo (Los Laureles)	64.0	Positive	Negative	Positive Salmonella sp, Enterobacter, and Citrobacter
--	*Rio Abajo (Los Laureles)	350.0	Negative	Negative	Positive Escherichia coli
--	La Majadita	64.0	Negative	Negative	Positive Escherichia coli

* This site (Los Laureles) was retested because of earlier findings of positive Salmonella. (Note: all tests performed in accordance with Standard Methods for the Examination of Water and Waste Water, 13th Edition APHA, 1971.)

Because of the high level of bacteria found in the water in Nicaragua, all sites will be analyzed further during this project to provide more insight into whether or not contamination is being sealed off from the water by the preparation of the wells and the installation of the pumps. The concrete structures of the sites in Nicaragua are exceptionally well made, and it will be surprising, indeed, if the quality of the water is not satisfactory.

CONCLUSIONS AND RECOMMENDATIONS

Monitoring of pump performance is in an advanced stage of the budgeted 12-month period, and sufficient data are available for arriving at reliable conclusions. There are obvious indications at the present time that most definitely encourage further manufacture, installation, and use of the AID pump. The AID pump can be manufactured in a developing country at a competitive, profitable price and at an acceptable level of quality if adequate facilities (foundries, pattern makers, machine shops and skilled machinists, raw materials, etc.) are available; however, the availability of adequate foundry facilities with acceptable pump prices and quality controls are matters that must be determined for each individual developing country. Public acceptance by rural villagers has been good, both from an aesthetic standpoint and from a standpoint of the pump being used easily by men, women, and children. Further, the AID pump should have a positive impact in developing countries on the health of rural people, on employment generation, on a positive balance of trade, and on instilling national pride within the people when it is seen that these countries do have local capabilities for manufacturing a relatively complicated product rather than importing it.

As indicated above, the AID pump (both the shallow-well and the deep-well version) is adaptable to local manufacture in developing countries if adequate facilities are available. While numerous manufacturing problems have been encountered in both Costa Rica and Nicaragua, the majority of these problems are problems that are to be expected when a product such as the AID pump is introduced into production for the first time. As subsequent orders are processed through the manufacturer's plant and as personnel become more familiar with the pump itself, quality control should be refined to the point where the orders are considered to be normal production. The Battelle drawings included in the Appendix of this report are adequate, with the following comments:

1. While the working drawings are generally satisfactory, a prototype of the shallow-well and/or the deep-well version of the AID pump is advisable if a manufacturer has not produced the pump before.

2. The epoxy-lined metal cylinder for the shallow-well pump slows down wear on leather cups but is less than desirable. The cylinder should be honed down smooth or have a PVC liner.

3. The AID deep-well pump cylinder made of PVC is far superior to the cylinder of metal that is coated with epoxy.

4. The AID deep-well modified cap for Costa Rica or for Nicaragua is acceptable. The Costa Rican cap is much simpler and cheaper to manufacture but will not hold up as long as the modified cap of Nicaragua. The modified cap being used in Nicaragua should also retard the wearing of cups because of its guided pump rod which the Costa Rican cap does not have.

5. The use of hardened steel bearing inserts at pivot points is sound and should be encouraged.

6. It is imperative that cups of good quality and size be used and that the tendency to make oversized cups be avoided.

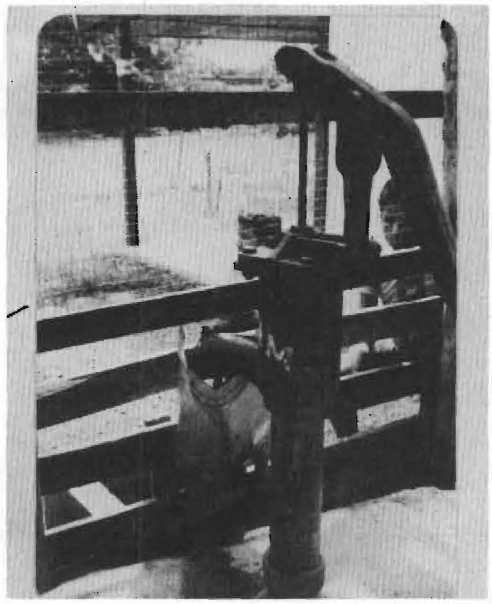
7. Any water system, including one using hand pumps, must include a field maintenance support system, for no pump can last indefinitely without maintenance.

Comparative pumps used in this field test were originally chosen because they were expected to hold up well during the test period. The Dempster pump is an extremely fine pump and has performed remarkably well but is rather expensive. The Brazilian "Marumby" pumps are beginning to fail and have been disappointing in their durability. The IDRC pump has good points that represent a lower level of technology than that required of the AID pump and is an alternative to the AID pump, especially where foundry facilities are not available but local manufacturing is desirable. The Japanese "Lucky" pump has performed extremely well but is a complicated pump and will, undoubtedly, present maintenance problems as the components begin to wear.

Lastly, this program of field testing the AID pump has presented many unforeseeable problems. However, the satisfaction of providing a means of safe, convenient water during this test period to rural villagers that heretofore have been getting their water from grossly polluted sources or have been walking many miles per day for small amounts of water necessary for survival has made all of the problems seem insignificant. As a result, Georgia Tech and ICAITI project personnel are grateful to the Agency for International Development for the opportunity to have participated in such a program.

Appendix 1

COSTA RICAN TEST SITES



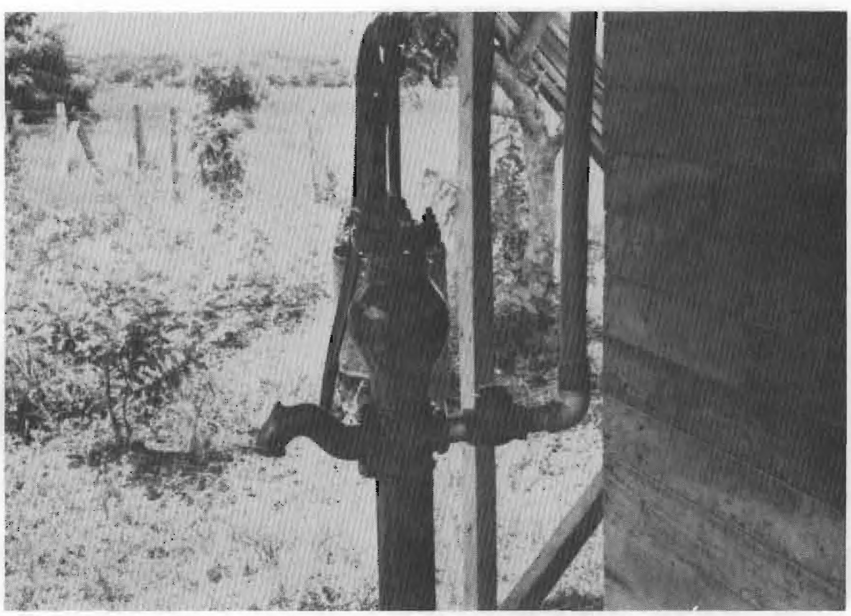
Site No. 1, located at La Palma de Abangares (AID deep-well pump).

Site No. 2, located at San Joaquin de Abangares (AID deep-well pump).

Site No. 3, located at IMAS, El Torito, Samara (AID shallow-well pump).

Site No. 4, located at Hernandez de Santa Cruz (Lucky shallow-well pump).

Site No. 5, located at Curime de Nicoya (Dempster pump).



Site No. 6, located at Pijije de Bagaces (Dempster pump).

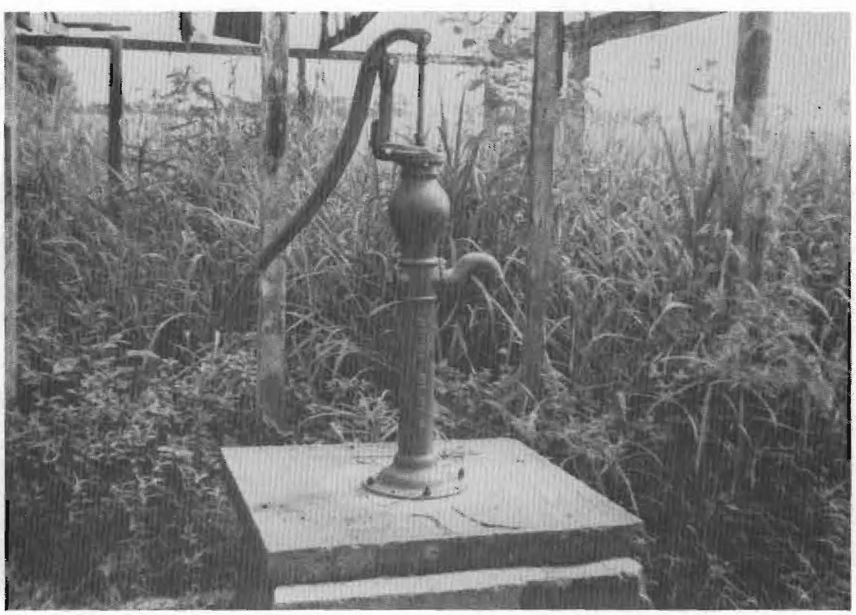
Site No. 7, located at La Javilla de Canas (AID shallow-well pump).

Site No. 8, located at Zent, Matina school (AID shallow-well pump).

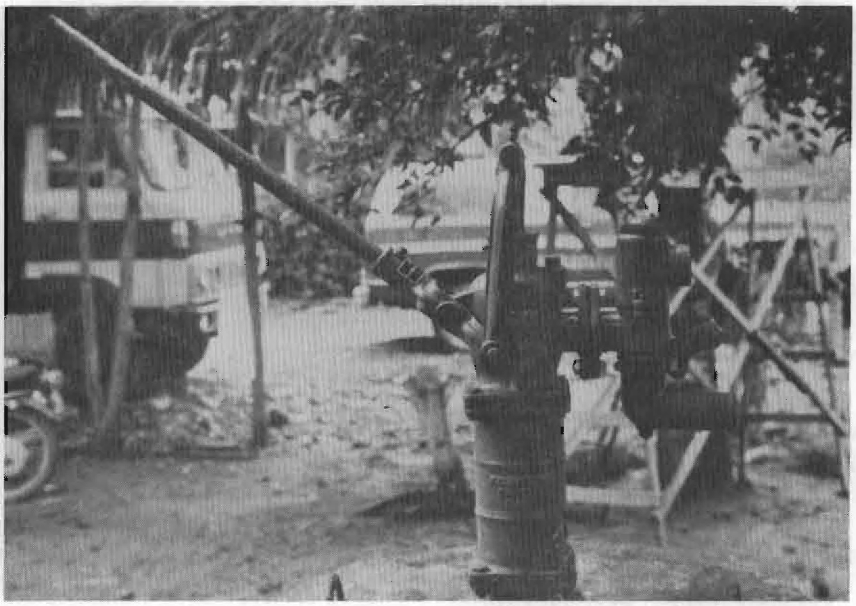
Site No. 9, located at Corina, Matina (AID shallow-well pump).

Site No. 10, located at Bristol, Matina (AID shallow-well pump).

Site No. 11, located at La Margarita, Bataan (Lucky pump).

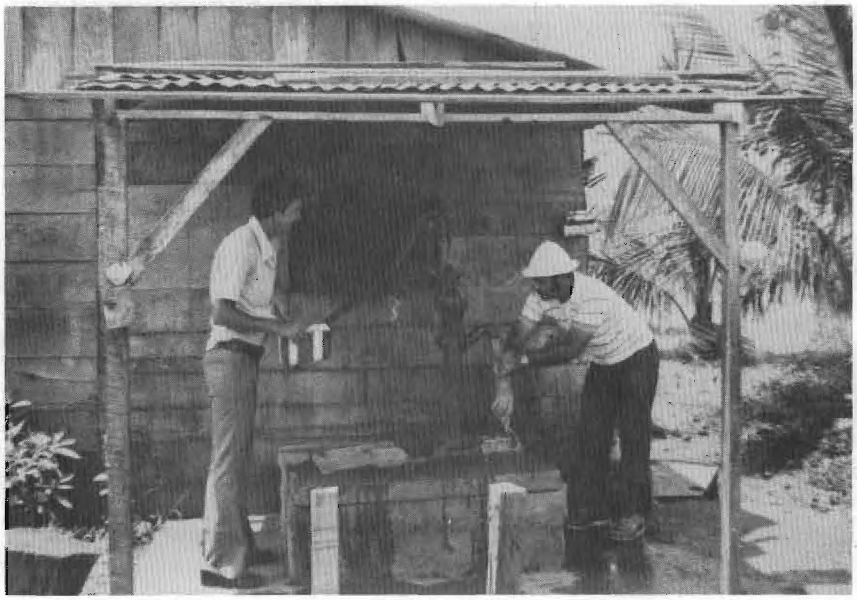


Site No. 12, located at Corazon de Jesus (Dempster pump).

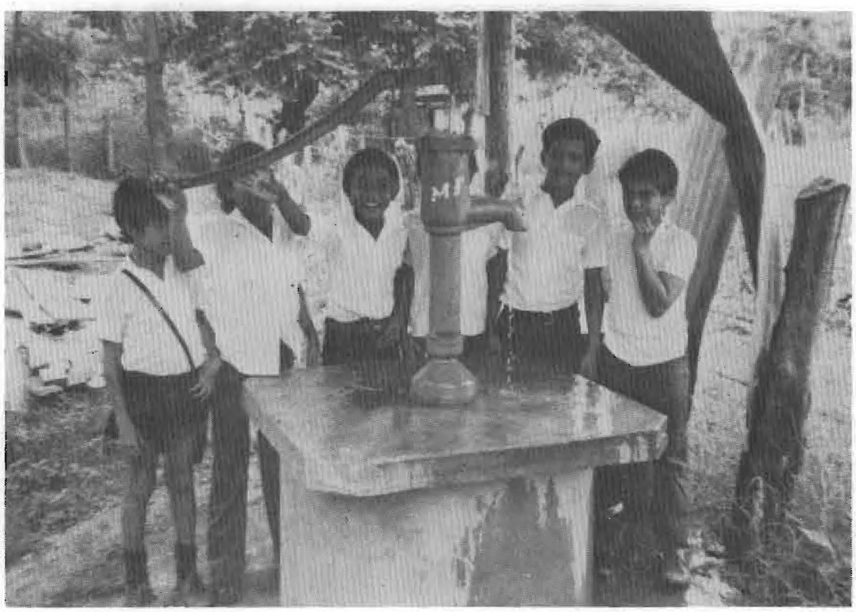


Site No. 13, located at Zent, Matina (Lucky pump).

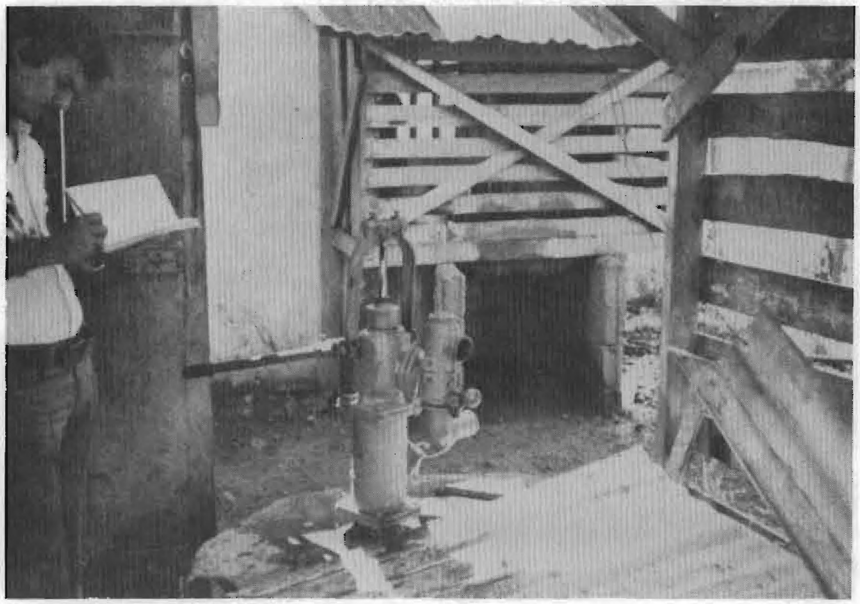
Site No. 14, located at San Miguel de Venado (Dempster pump).



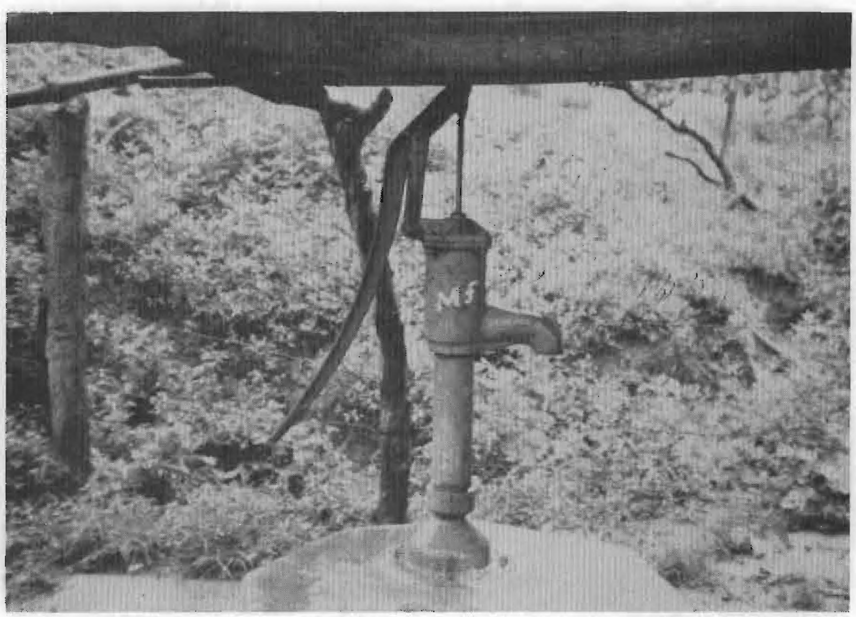
Site No. 15, located at Sabalito de Venado (Dempster pump).



Site No. 16, located at Pueblo Nuevo de Colorado (AID shallow-well pump).



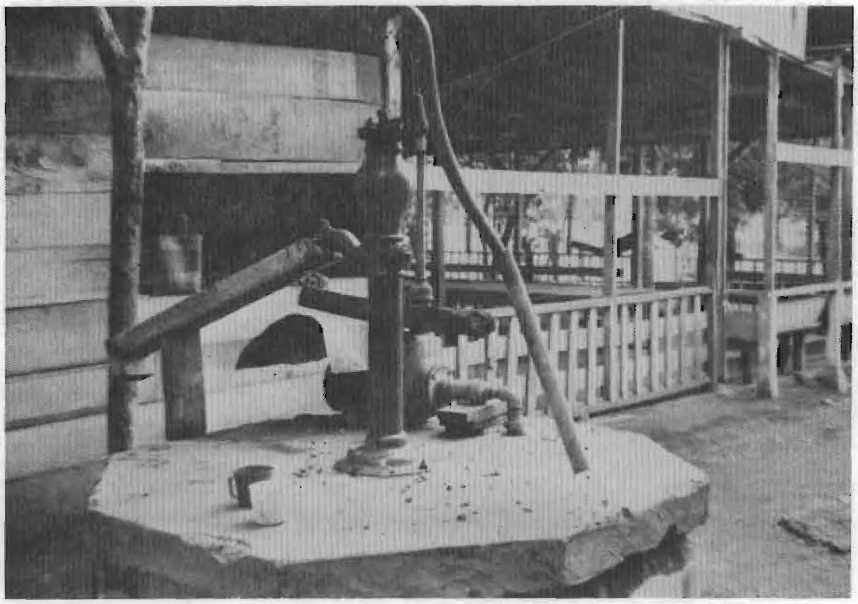
Site No. 17, located at San Francisco de Santa Cruz (Lucky pump).



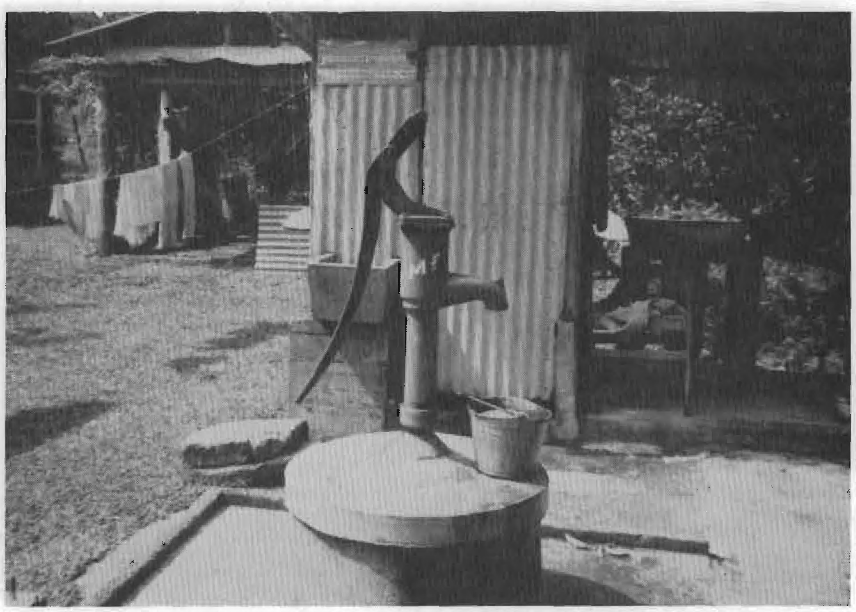
Site No. 18, located at Terciopelo de Nicoya (AID deep-well pump).

Site No. 19, located at Caimitalito de Nicoya (AID deep-well pump).

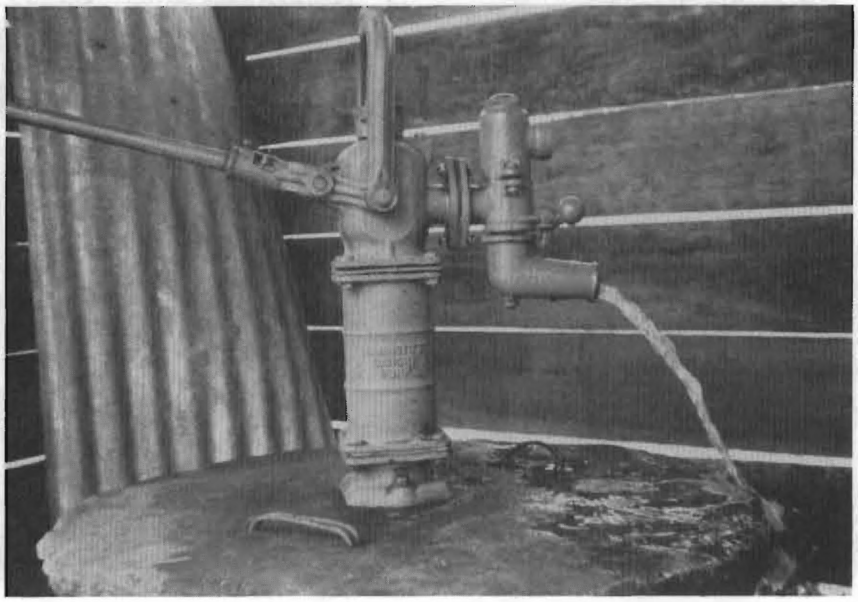
Site No. 20, located at Judas de Chomes (Dempster pump).



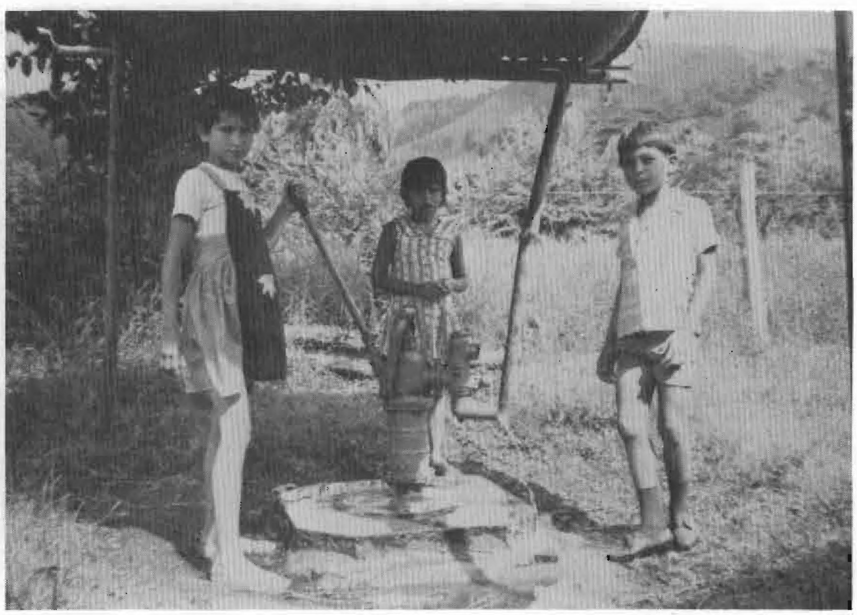
Site No. 21, located at Limonal de Abangares (Dempster pump).



Site No. 22, located at Zent, Matina (AID shallow-well pump).

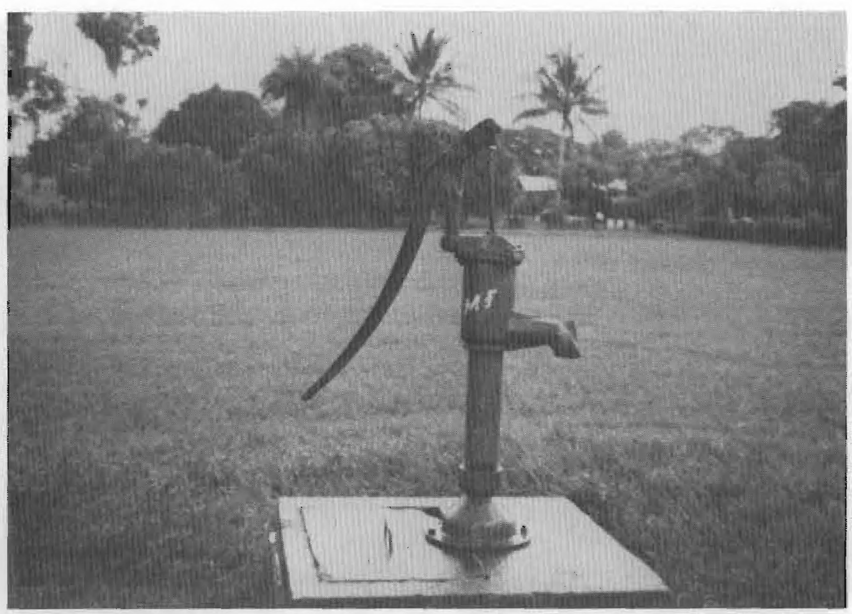


Site No. 23, located at Santa Marta de Matina (Lucky pump).

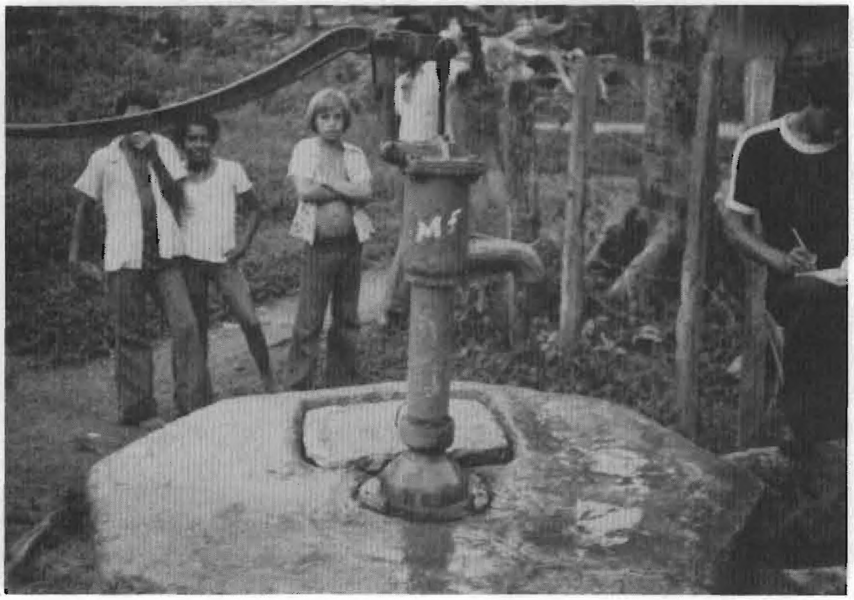


Site No. 24, located at Tarcolesa de Orotina (Lucky pump).

Site No. 25, located at Mesetas Abajo (Lucky pump).



Site No. 26, located at San Juan Grande (AID deep-well pump).



Site No. 27, located at Sabana Grande (AID deep-well pump).

Site No. 28, located at Cuyolito de Santa Cruz (AID deep-well pump).

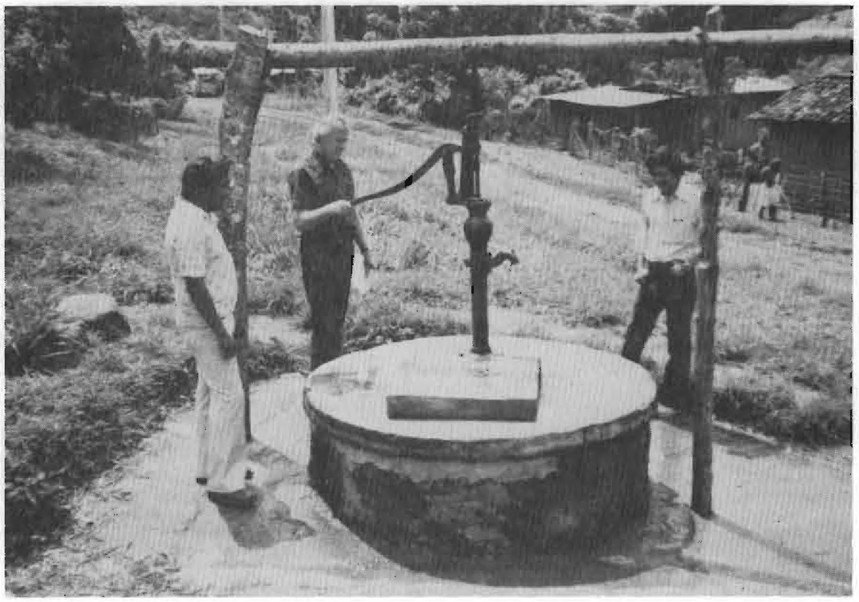
Site No. 29, located at La Lorena de Santa Cruz (Dempster pump).

Site No. 30, located at Lajas de Canas (AID deep-well pump).

Site No. 31, located at Indiana Tres-Siquirres (AID shallow-well pump).

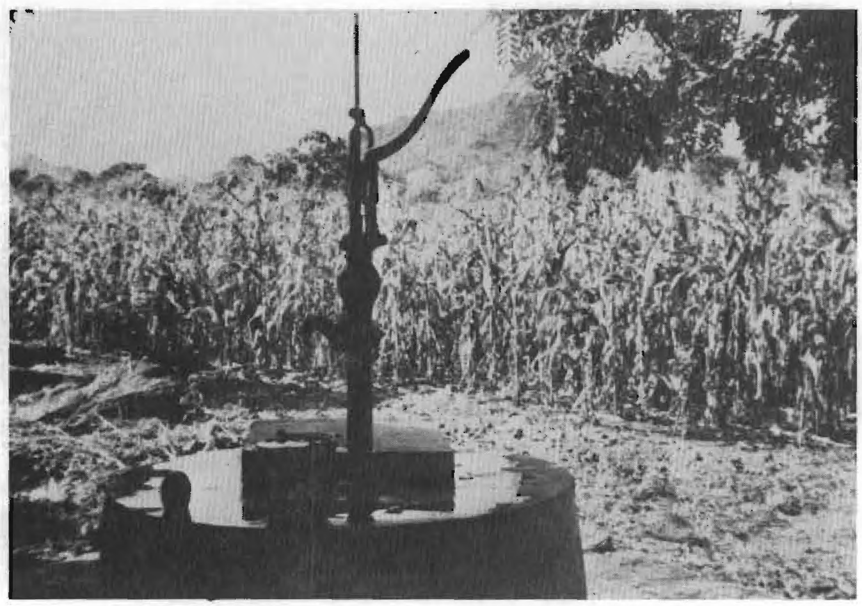
Appendix 2

NICARAGUAN TEST SITES

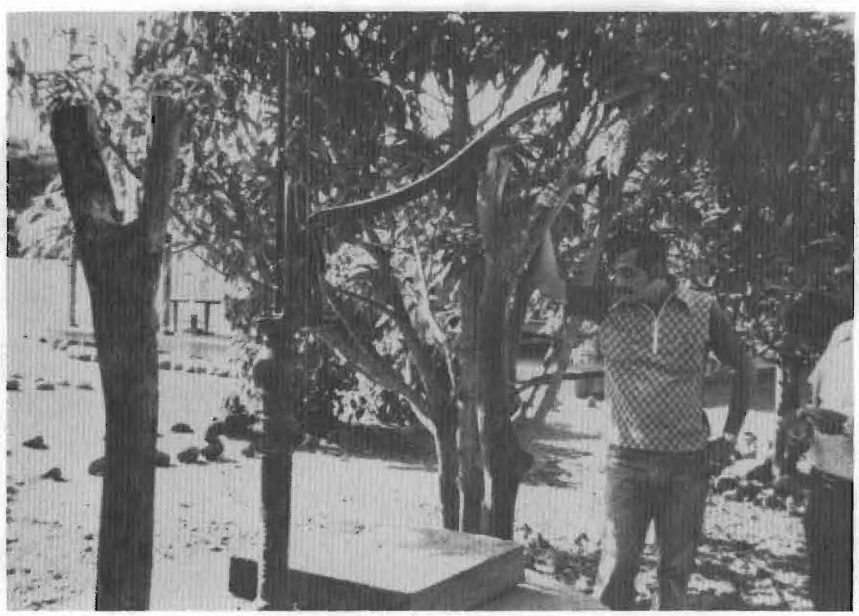


Nicaragua Site No. 1, located at La Garita (Dempster pump).

Nicaragua Site No. 2, located at Las Lajitas (Marumby shallow-well pum).



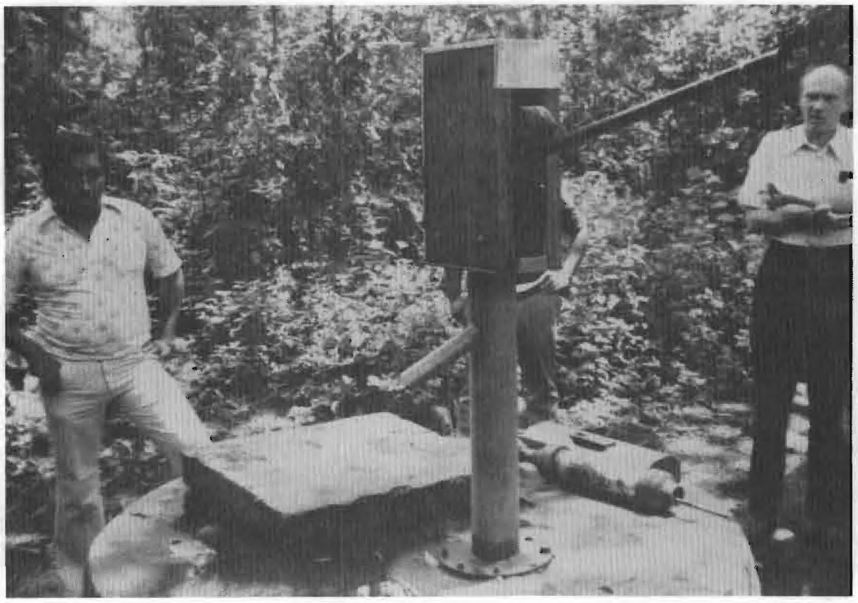
Nicaragua Site No. 3, located at La Lamilla (Dempster pump).



Nicaragua Site No. 4, located at San Antonio (Dempster pump).

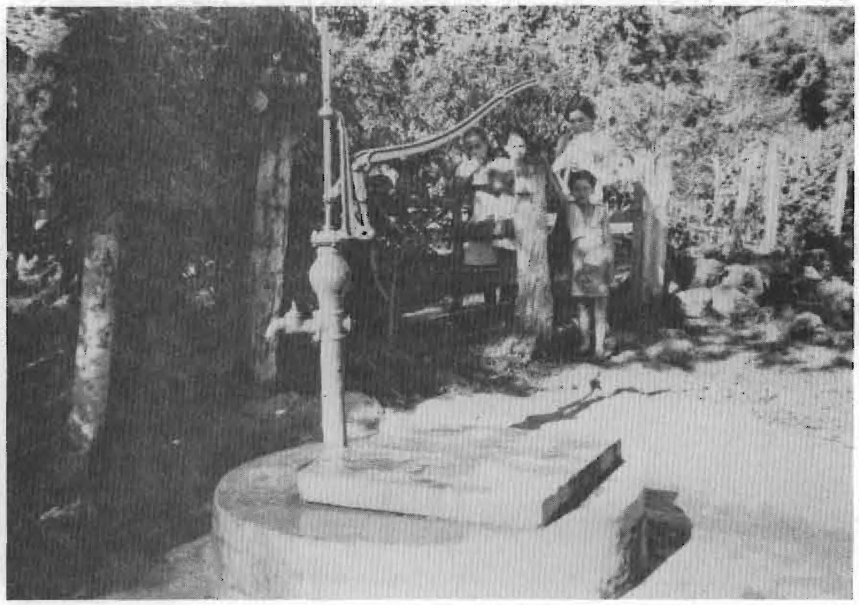
Nicaragua Site No. 5, located at Las Mesas (Marumby shallow-well pump).

Nicaragua Site No. 6, located at Las Mangas (AID deep-well pump).



Nicaragua Site No. 7, located at Llano Grande (IDRC pump).

Nicaragua Site No. 8, located at San Diego (Marumby shallow-well pump).

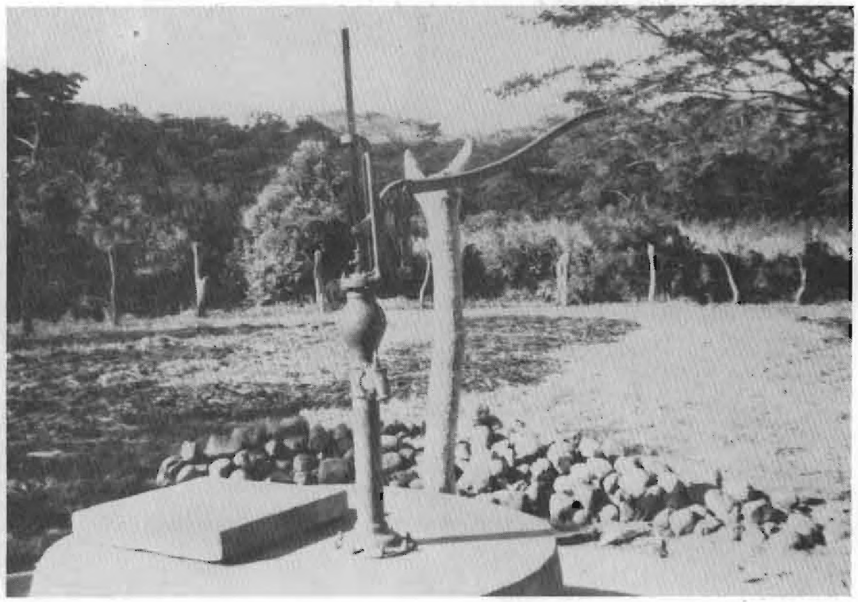


Nicaragua Site No. 9, located at Mechapa (Dempster pump).

Nicaragua Site No. 10, located at El Naranjo (AID shallow-well pump).

Nicaragua Site No. 11, located at Isidrillo (Dempster pump).

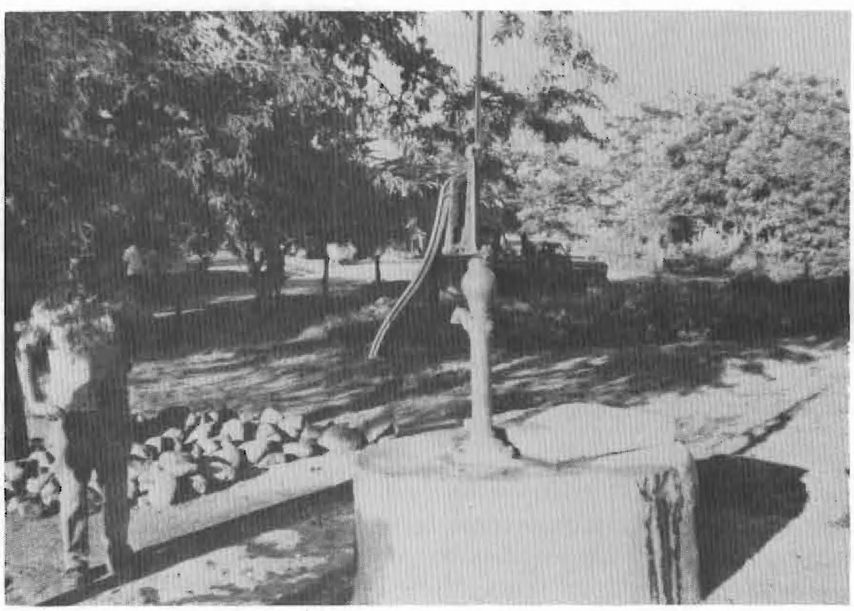
Nicaragua Site No. 12, located at La Concepcion (AID shallow-well pump).



Nicaragua Site No. 13, located at El Rodeo (Dempster pump).

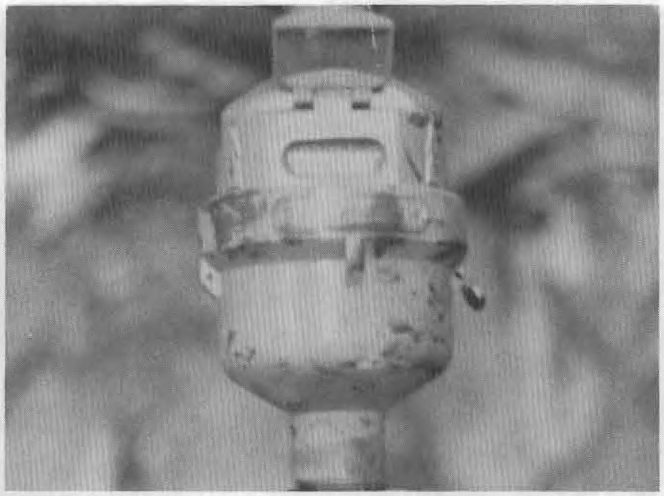
Nicaragua Site No. 14, located at Los Calpules stream (AID shallow-well pump).

Nicaragua Site No. 15, located at Los Calpules school (Dempster pump).



Nicaragua Site No. 16, located at Paso Hondo (Dempster pump).

Nicaragua Site No. 17, located at Quebrada Ariba (Marumby shallow-well pump).

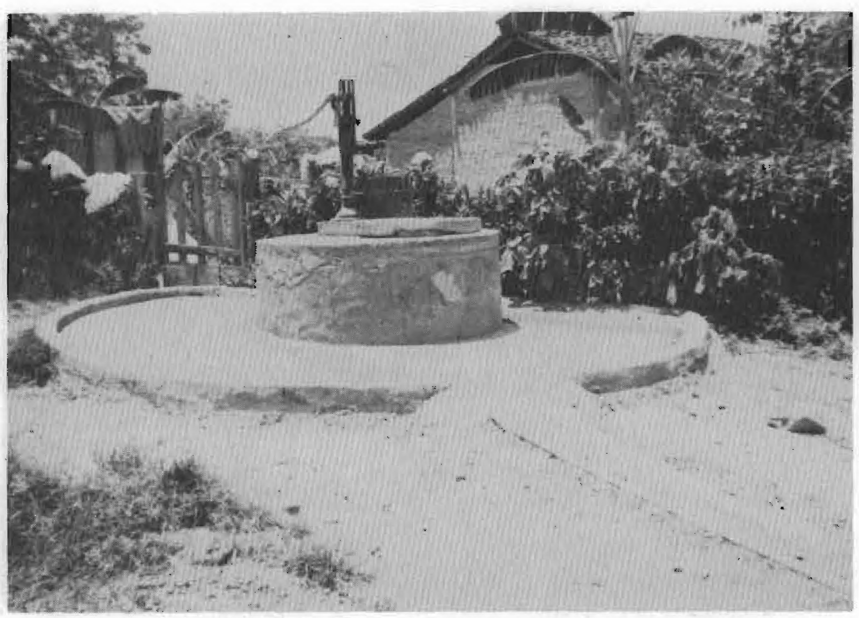


In order to better understand water consumption patterns of the users of test pumps, water meters have been installed at representative sites in both Nicaragua and Costa Rica. These water meters will accurately record the amount of water, in gallons, that passes through the pumps during a given period of time and will provide data to complement user figures based on village population. Sites having water meters, in Nicaragua, are Las Lajitas (Site No. 2), San Antonio (Site No. 4), Santa Rosa (Site No. 23) and El Espinal (Sites No. 28 and 29).

Nicaragua Site No. 18, located at Las Lajas (AID shallow-well pump).

Nicaragua Site No. 19, located at Los Hatillos community plaza (AID deep-well pump).

Nicaragua Site No. 20, located at Los Hatillos (AID deep-well pump).

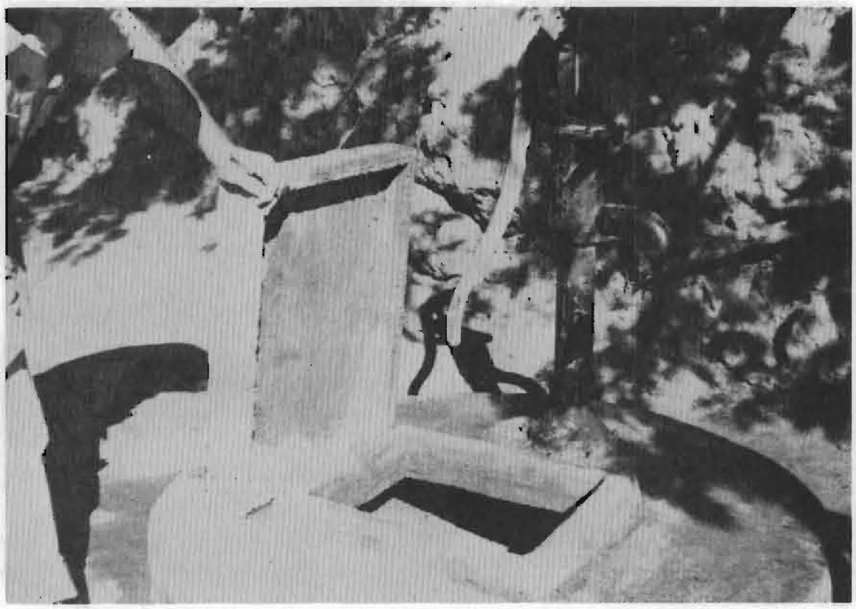


Nicaragua Site No. 21, located at Musuli (AID deep-well pump).

Nicaragua Site No. 22, located at Los Rincones (AID deep-well pump).

Nicaragua Site No. 23, located at Santa Rosa (AID deep-well pump).

Nicaragua Site No. 24, located at El Jocote (AID deep-well pump).



Nicaragua Site No. 25, located at Mechapa-La Concepcion (AID shallow-well pump).

Nicaragua Site No. 26, located at Licoroy (AID shallow-well pump).

Nicaragua Site No. 27, located at Tomabu (AID shallow-well pump).

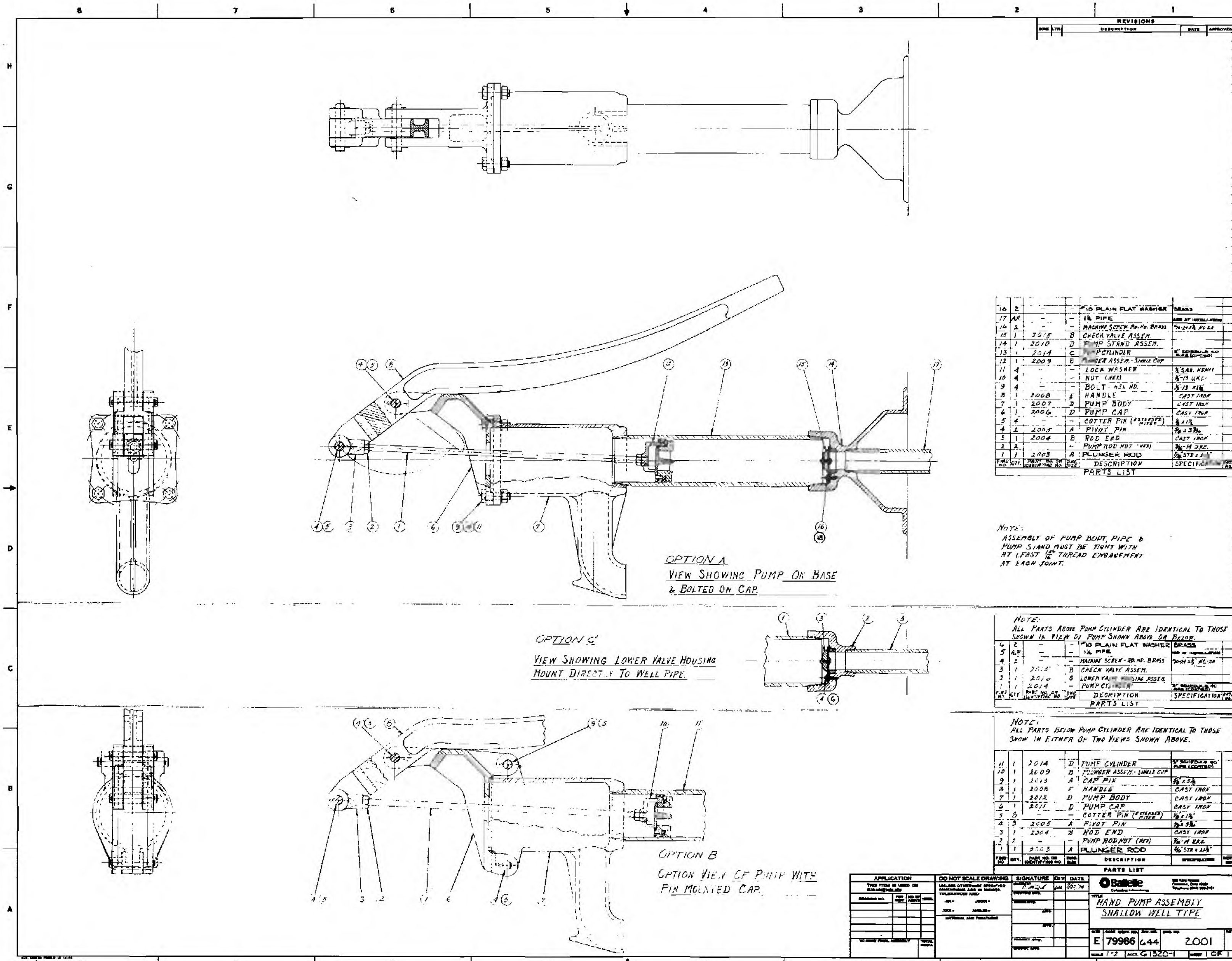
Nicaragua Site No. 28, located at El Espinal (AID shallow-well pump).

Nicaragua Site No. 29, located at El Espinal (AID shallow-well pump).

Nicaragua Site No. 30, located at Sabana Grande (Marumby shallow-well pump).

Appendix 3

AID/BATTELLE PUMP WORKING DRAWINGS



NOTE:
ASSEMBLY OF PUMP BODY, PIPE & PUMP STAND MUST BE TIGHT WITH AT LEAST $\frac{13}{16}$" THREAD ENGAGEMENT AT EACH JOINT.

FIND NO.	QTY.	PART NO. OR IDENTIFYING NO.	DWG. SIZE	DESCRIPTION	SPECIFICATION	NOTE NO.
18	2	–	–	#10 PLAIN FLAT WASHER	BRASS	
17	A.R.	–	–	1¼ PIPE	[illegible]	
16	2	–	–	MACHINE SCREW RD. HD. BRASS	#10-24 x 1½ NC-2A	
15	1	2015	B	CHECK VALVE ASSEM.		
14	1	2010	D	PUMP STAND ASSEM.		
13	1	2014	C	PUMP CYLINDER	3" SCHEDULE 40 PIPE (COATED)	
12	1	2009	B	PLUNGER ASSEM. - SINGLE CUP		
11	4	–	–	LOCK WASHER	⅝ SAE. HEAVY	
10	4	–	–	NUT (HEX)	⅝-13 UNC	
9	4	–	–	BOLT - HEX HD.	⅝-13 x 1½	
8	1	2008	E	HANDLE	CAST IRON	
7	1	2007	D	PUMP BODY	CAST IRON	
6	1	2006	D	PUMP CAP	CAST IRON	
5	4	–	–	COTTER PIN (EXTENDED MITER)	⅛ x 1¼	
4	2	2005	A	PIVOT PIN	⅝ x 3⁵⁄₁₆	
3	1	2004	B	ROD END	CAST IRON	
2	2		–	PUMP ROD NUT (HEX)	⁷⁄₁₆-14 UNC.	
1	1	2003	A	PLUNGER ROD	⁷⁄₁₆ STD x [illegible]	

PARTS LIST

NOTE:
ALL PARTS ABOVE PUMP CYLINDER ARE IDENTICAL TO THOSE SHOWN IN VIEW OF PUMP SHOWN ABOVE OR BELOW.

FIND NO.	QTY.	PART NO. OR IDENTIFYING NO.	DWG. SIZE	DECRIPTION	SPECIFICATION	NOTE NO.
6	2	–	–	#10 PLAIN FLAT WASHER	BRASS	
5	A.R.	–	–	1¼ PIPE	[illegible]	
4	2	–	–	MACHINE SCREW - RD. HD. BRASS	#10-24 x ⅝ NC-2A	
3	1	2015	B	CHECK VALVE ASSEM.		
2	1	2016	C	LOWER VALVE HOUSING ASSEM.		
1	1	2014	–	PUMP CYLINDER	3" SCHEDULE 40 PIPE (COATED)	

PARTS LIST

NOTE:
ALL PARTS BELOW PUMP CYLINDER ARE IDENTICAL TO THOSE SHOW IN EITHER OF TWO VIEWS SHOWN ABOVE.

FIND NO.	QTY.	PART NO. OR IDENTIFYING NO.	DWG. SIZE	DESCRIPTION	SPECIFICATION	NOTE NO.
11	1	2014	D	PUMP CYLINDER	3" SCHEDULE 40 PIPE (COATED)	
10	1	2009	B	PLUNGER ASSEM. - SINGLE CUP		
9	1	2013	A	CAP PIN	⅝ x 5⅛	
8	1	2008	F	HANDLE	CAST IRON	
7	1	2012	D	PUMP BODY	CAST IRON	
6	1	2011	D	PUMP CAP	CAST IRON	
5	6	–	–	COTTER PIN (EXTENDED MITER)	⅛ x 1¼	
4	3	2005	A	PIVOT PIN	⅝ x 3⁵⁄₁₆	
3	1	2004	B	ROD END	CAST IRON	
2	2	–	–	PUMP ROD NUT (HEX)	⁷⁄₁₆-14 UNC.	
1	1	2003	A	PLUNGER ROD	⁷⁄₁₆ STD x 22⅝	

PARTS LIST

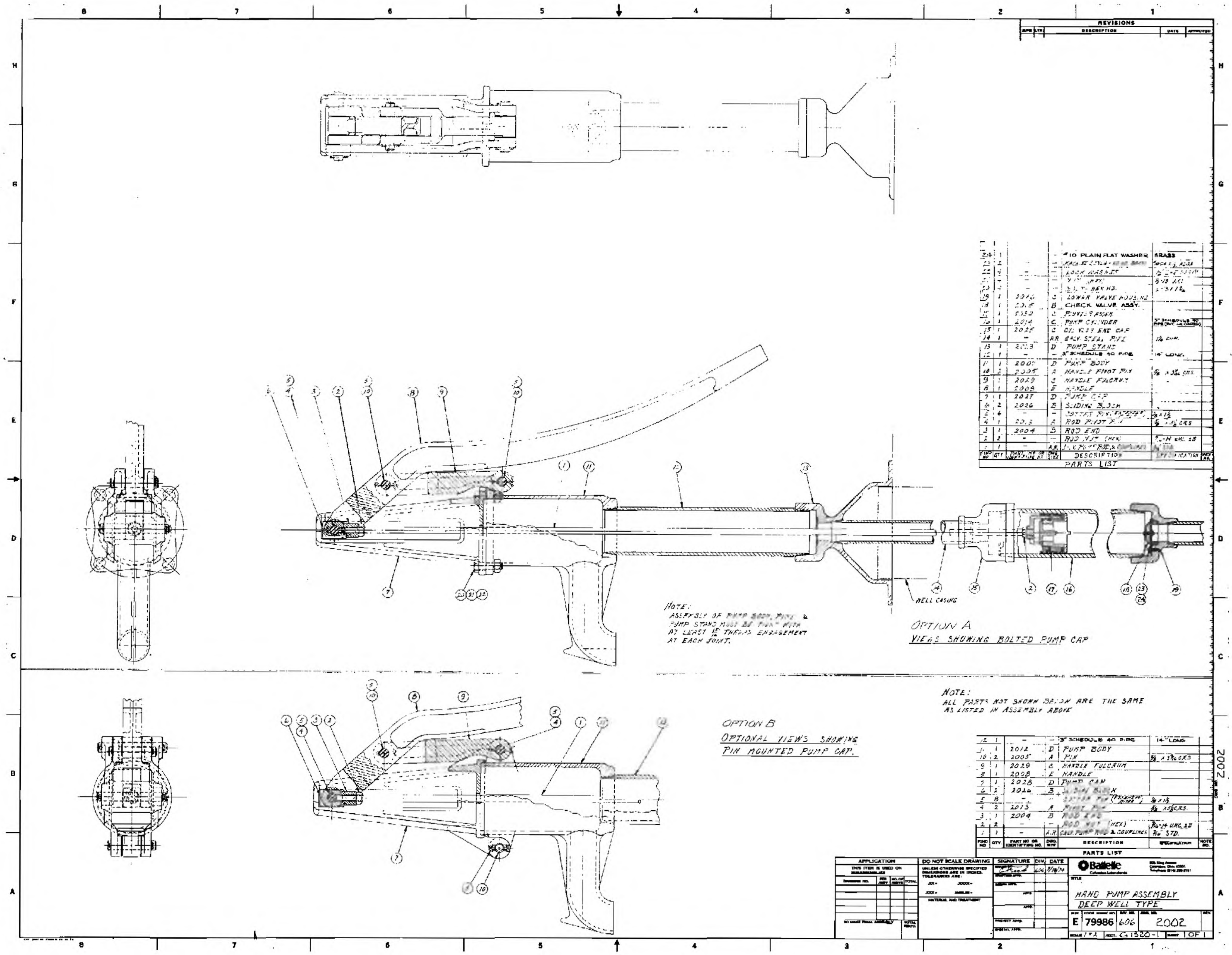
APPLICATION | DO NOT SCALE DRAWING | SIGNATURE | DIV. | DATE

Battelle
Columbus Laboratories

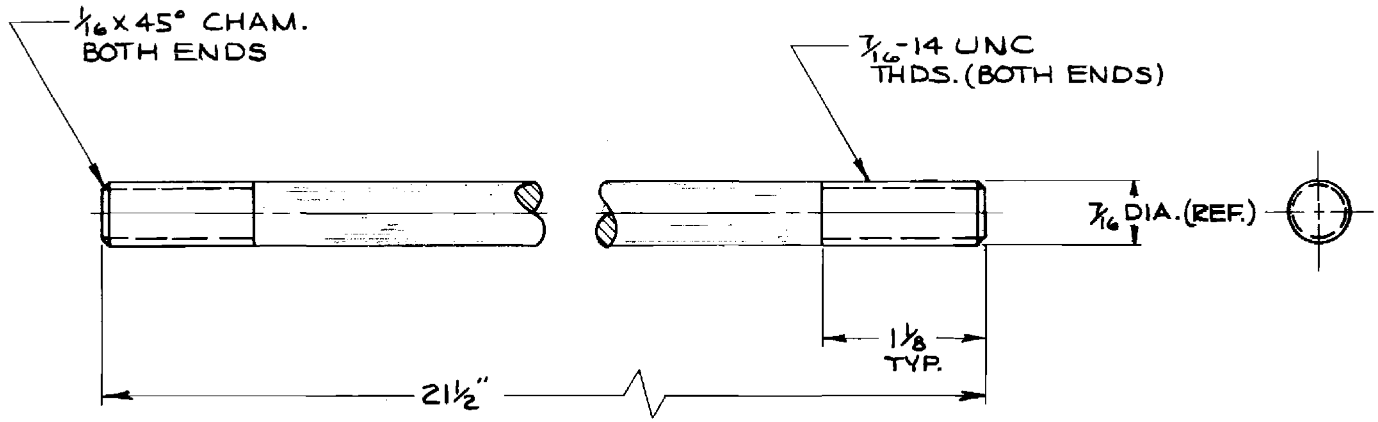
TITLE: HAND PUMP ASSEMBLY SHALLOW WELL TYPE

SIZE: E | CODE IDENT NO.: 79986 | 644 | DWG. NO.: 2001

SCALE 1:2 | G1520-1 | SHEET 1 OF 1


REVISIONS
NOTE:
ASSEMBLY OF PUMP BODY, PIPE & PUMP STAND MUST BE TIGHT WITH AT LEAST 1½ THREAD ENGAGEMENT AT EACH JOINT.
WELL CASING
OPTION A
VIEWS SHOWING BOLTED PUMP CAP
OPTION B
OPTIONAL VIEWS SHOWING PIN MOUNTED PUMP CAP.
NOTE:
ALL PARTS NOT SHOWN BELOW ARE THE SAME AS LISTED IN ASSEMBLY ABOVE
#10 PLAIN FLAT WASHER
BRASS
CHECK VALVE ASSY.
3" SCHEDULE 40 PIPE
14" LONG
PUMP BODY
HANDLE PIVOT PIN
HANDLE FULCRUM
HANDLE
PUMP CAP
SLIDING BLOCK
ROD PIVOT PIN
ROD END
ROD NUT (HEX)
LOWER VALVE HOUSING
PUMP CYLINDER
GALV. STEEL PIPE
PUMP STAND
DESCRIPTION
PARTS LIST
FIND NO
QTY
PART NO OR IDENTIFYING NO.
DWG SIZE
SPECIFICATION
NOTE NO.
APPLICATION
DO NOT SCALE DRAWING
UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES. TOLERANCES ARE:
MATERIAL AND TREATMENT
SIGNATURE
DIV
DATE
Battelle
Columbus Laboratories
TITLE
HAND PUMP ASSEMBLY
DEEP WELL TYPE
E
79986
606
2002
G1320-1
1 OF 1

REVISIONS			
LTR	DESCRIPTION	DATE	APPROVED



APPLICATION			
THIS ITEM IS USED ON SUBASSEMBLIES			
DRAWING NO.	PER ASSY	NO. OF ASSYS	TOTAL
2001	1	1	1
TO MAKE FINAL ASSEMBLY			TOTAL REQ'D.

DO NOT SCALE DRAWING

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES. TOLERANCES ARE: ±1/32

.XX = – .XXXX = –

.XXX = – ANGLES = ±1/2°

MATERIAL & TREATMENT

7/16 DIA. GALV.
PUMP ROD

SIGNATURE	DIV.	DATE
DRAWN BY [illegible]	455	1-7-75
DRAFTING APPD.		
DESIGN APPD.		
APPD.		
PROJECT APPD.		
SPECIAL APPD.		

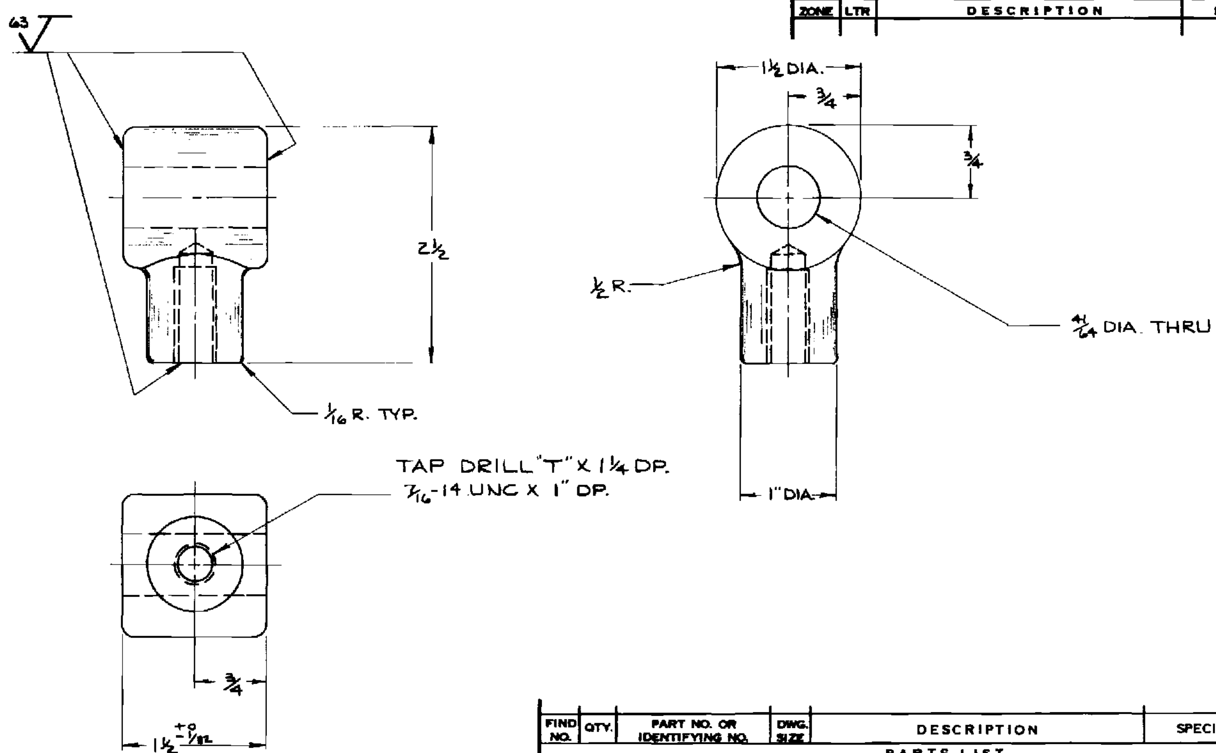
BATTELLE MEMORIAL INSTITUTE
COLUMBUS LABORATORIES
505 KING AVE., COLUMBUS, OHIO 43201

TITLE PLUNGER ROD

SIZE	CODE IDENT. NO.	DIV. NO.	DWG. NO.	REV.
A	79986	644	2003	

SCALE 1"=1" ACCT. G1320-1 SHEET 1 OF 1

CAT. 294163 FORM D-5 5-70



NOTES:

1. ALL DRAFT ANGLES TO BE 1½° TO 4°
2. ALL FILLETS & RADII TO BE ⅛" R. UNLESS OTHERWISE SPECIFIED

REVISIONS

ZONE	LTR	DESCRIPTION	DATE	APPROVED

PARTS LIST

FIND NO.	QTY.	PART NO. OR IDENTIFYING NO.	DWG. SIZE	DESCRIPTION	SPECIFICATION	NOTE NO.

APPLICATION

THIS ITEM IS USED ON ASSEMBLIES

DRAWING NO.	PER ASSY	NO. OF ASSYS	TOTAL
2001	1	1	1
2002	1	1	1

TO MAKE FINAL ASSEMBLY | TOTAL REQ'D.

DO NOT SCALE DRAWING

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES. TOLERANCES ARE: ± 1/32

.XX = — .XXXX = —
.XXX = — ANGLES = —

MATERIAL & TREATMENT: CAST IRON

SIGNATURE	DIV.	DATE
DRAWN BY	659	1-8-76
DRAFTING APPD.		
DESIGN APPD.		
APPD.		
PROJECT APPD.		
SPECIAL APPD.		

Battelle Columbus Laboratories
505 King Avenue
Columbus, Ohio 43201
Telephone (614) 299-3151

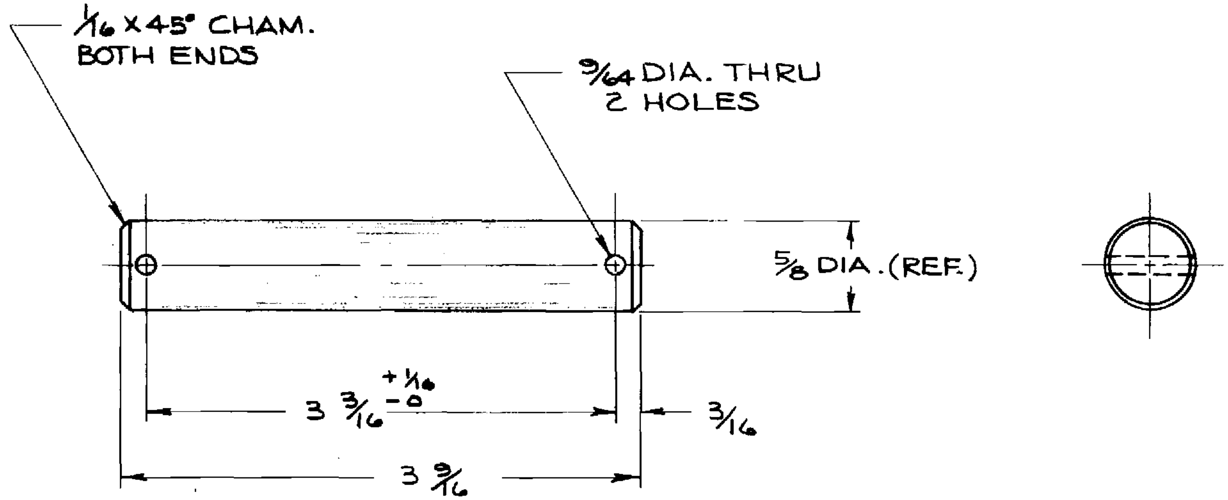
TITLE: ROD END

SIZE	CODE IDENT. NO.	DIV. NO.	DWG. NO.	REV.
B	79986	644	2004	

SCALE 1" = 1" ACCT. G1320-1 SHEET 1 OF 1

CAT. 594168 FORM D-7 12-72

REVISIONS			
LTR	DESCRIPTION	DATE	APPROVED



APPLICATION			
THIS ITEM IS USED ON ASSEMBLIES			
DRAWING NO.	PER ASSY	NO. OF ASSYS	TOTAL
2002	2	1	2
2001 "A"	2	1	2
2001 "B"	3	1	3
TO MAKE FINAL ASSEMBLY			TOTAL REQ'D.

DO NOT SCALE DRAWING

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES. TOLERANCES ARE: ±1/32

.XX = — .XXXX = —

.XXX = — ANGLES = ±1/2°

MATERIAL & TREATMENT
5/8 DIA. C.R.S. ROUND

SIGNATURE	DIV.	DATE
DRAWN BY	659	1-7-74
DRAFTING APPD.		
DESIGN APPD.		
APPD.		
PROJECT APPD.		
SPECIAL APPD.		

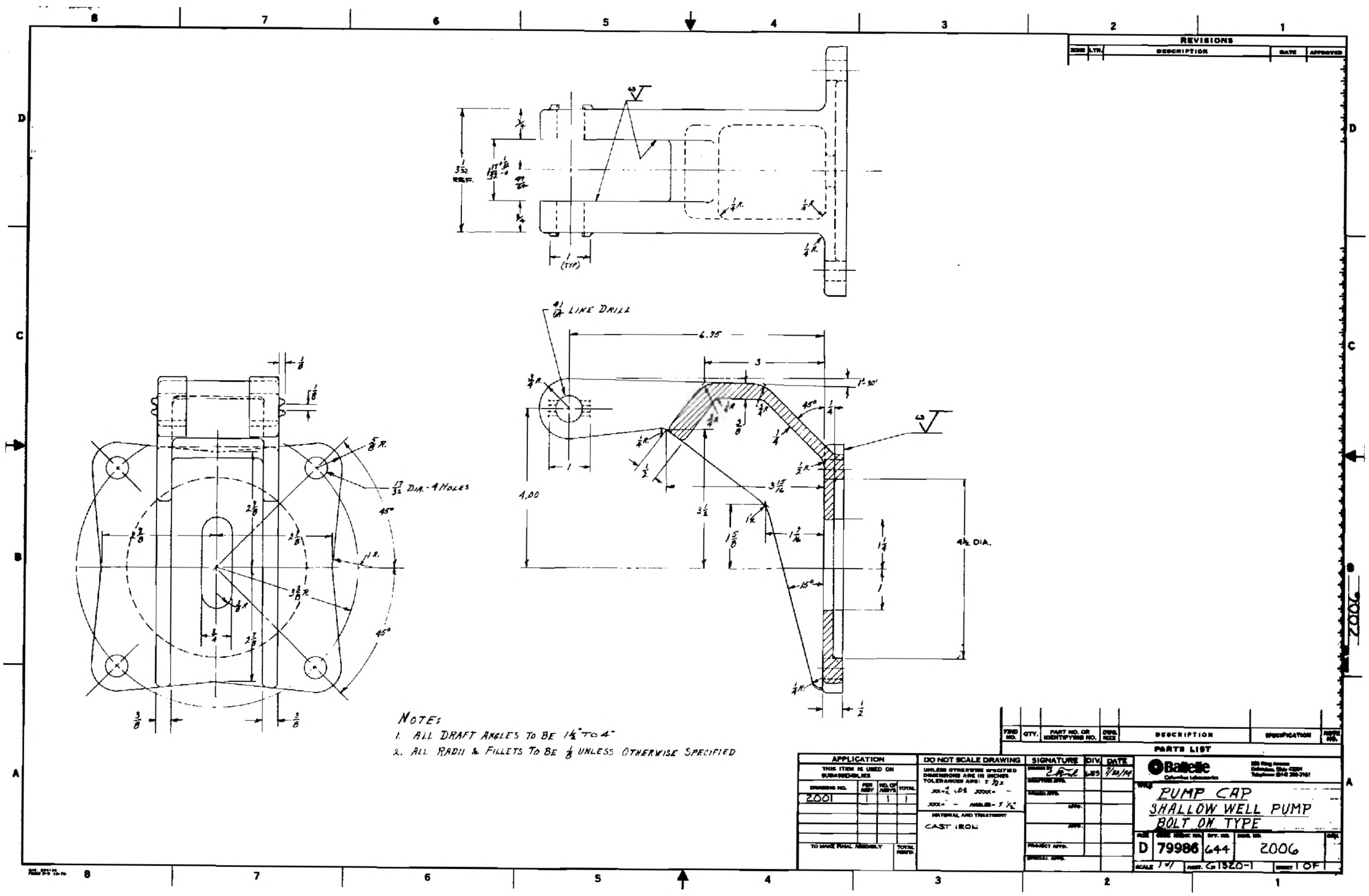
BATTELLE MEMORIAL INSTITUTE
COLUMBUS LABORATORIES
505 KING AVE., COLUMBUS, OHIO 43201

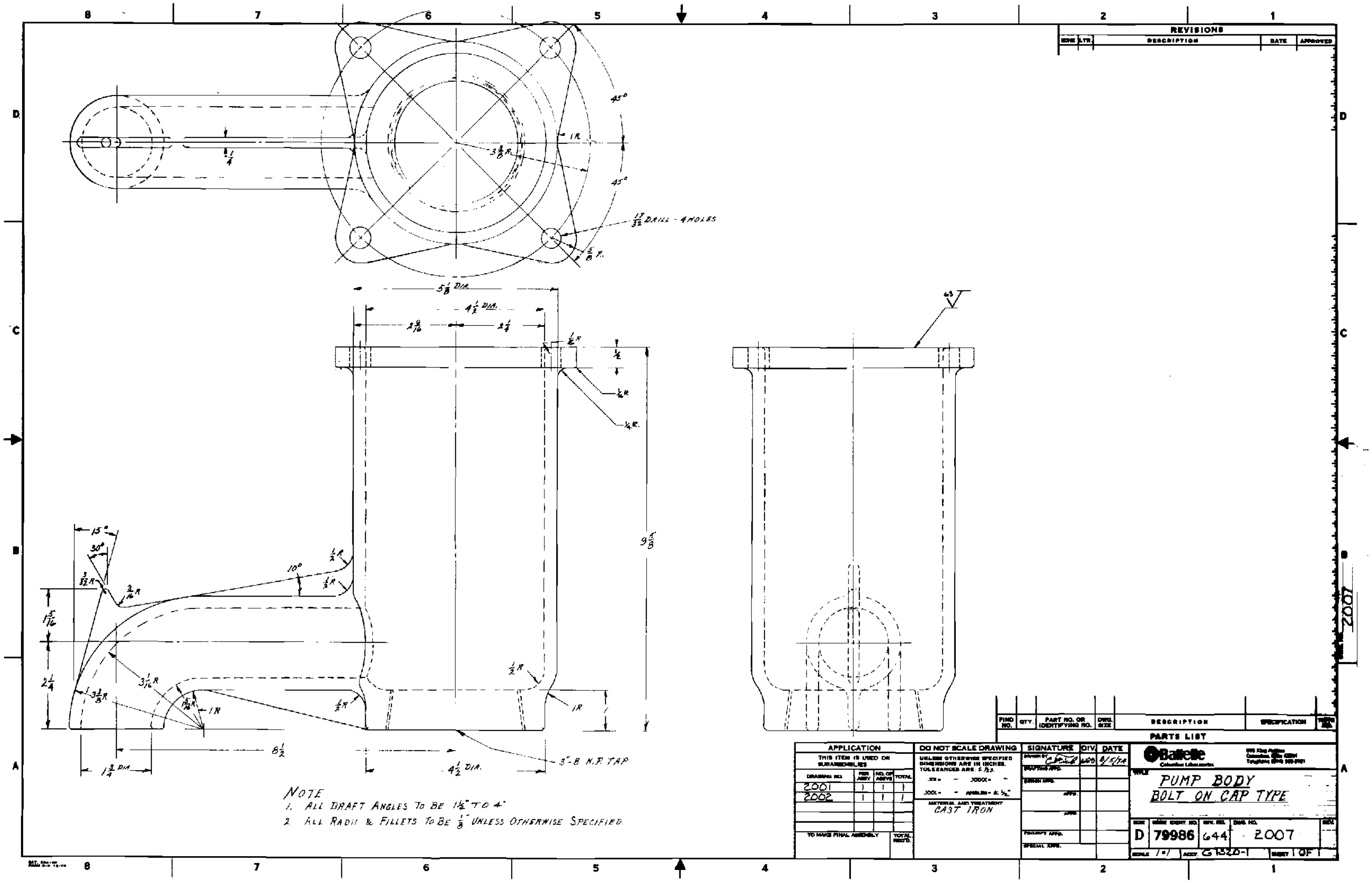
TITLE HANDLE PIVOT PIN

SIZE	CODE IDENT. NO.	DIV. NO.	DWG. NO.	REV.
A	79986	644	2005	

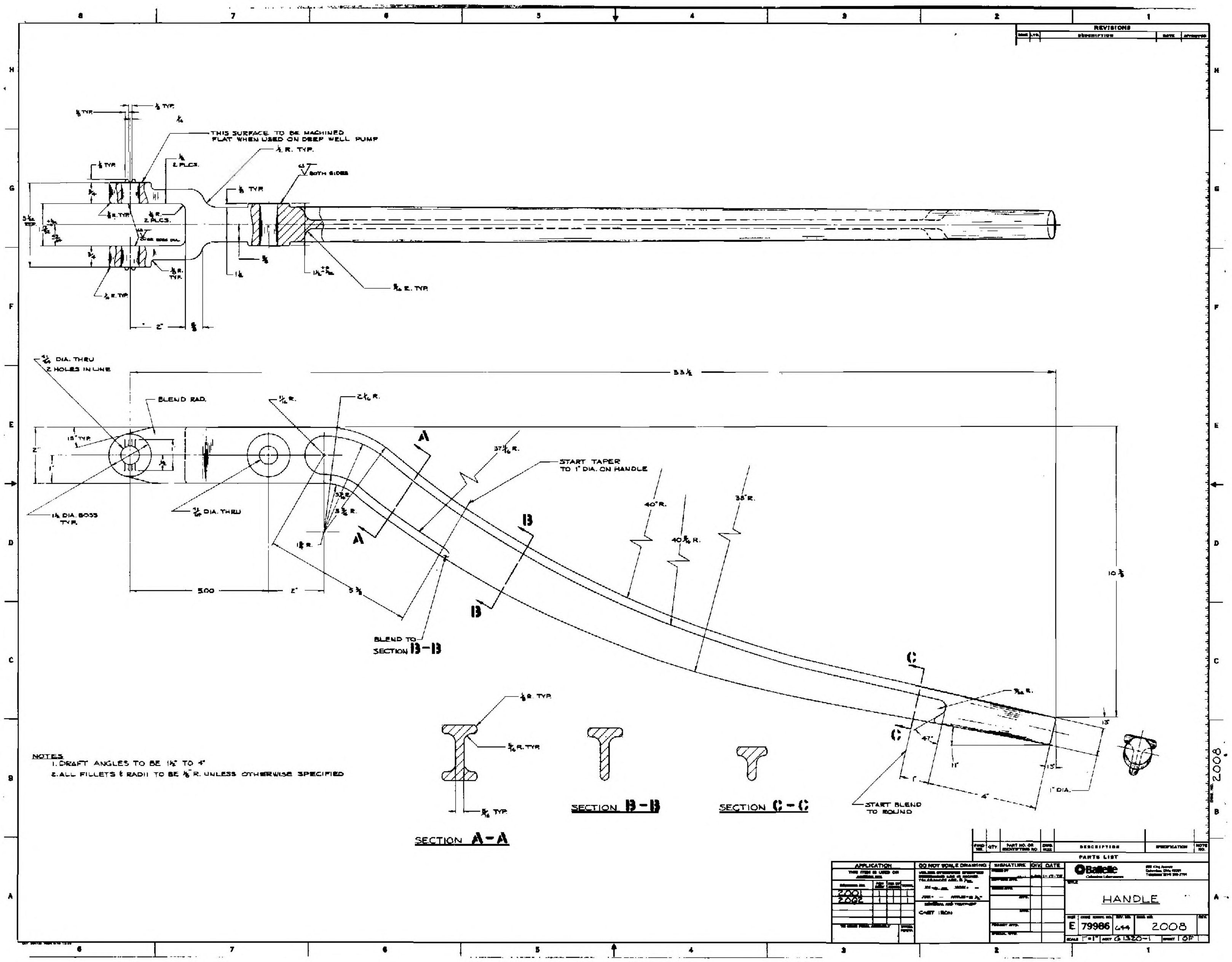
SCALE 1" = 1" ACCT. G1320-1 SHEET 1 OF 1

CAT. 294163 FORM D-5 5-70

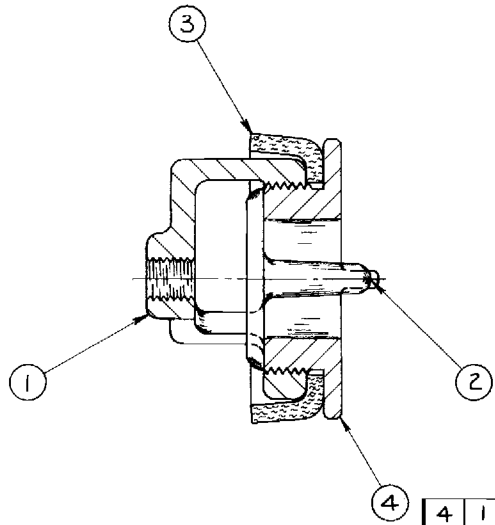

REVISIONS
ZONE
LTR.
DESCRIPTION
DATE
APPROVED
$\frac{41}{64}$ LINE DRILL
4½ DIA.
$\frac{17}{32}$ DIA. - 4 HOLES
NOTES:
1. ALL DRAFT ANGLES TO BE 1½° TO 4°
2. ALL RADII & FILLETS TO BE $\frac{1}{8}$ UNLESS OTHERWISE SPECIFIED
FIND NO.
QTY.
PART NO. OR IDENTIFYING NO.
DWG. SIZE
DESCRIPTION
SPECIFICATION
PARTS LIST
APPLICATION
THIS ITEM IS USED ON SUBASSEMBLIES
DRAWING NO.
PER ASSY
NO. OF ASSYS
TOTAL
2001
TO MAKE FINAL ASSEMBLY
TOTAL REQ'D
DO NOT SCALE DRAWING
UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES
MATERIAL AND TREATMENT
CAST IRON
SIGNATURE
DIV.
DATE
PROJECT APPD.
Battelle
Columbus Laboratories
PUMP CAP
SHALLOW WELL PUMP
BOLT ON TYPE
D
79986
644
2006
G1320-1
1 OF



REVISIONS
NOTE
1. ALL DRAFT ANGLES TO BE 1½° TO 4°
2. ALL RADII & FILLETS TO BE ⅛" UNLESS OTHERWISE SPECIFIED.
$\frac{17}{32}$ DRILL - 4 HOLES
3/8 N.P. TAP
PARTS LIST
APPLICATION
DO NOT SCALE DRAWING
UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES.
MATERIAL AND TREATMENT
CAST IRON
SIGNATURE
DIV.
DATE
4/5/74
2001
2002
Battelle
Columbus Laboratories
PUMP BODY
BOLT ON CAP TYPE
D
79986
644
2007
G 1320-1
1 OF 1



REVISIONS
THIS SURFACE TO BE MACHINED FLAT WHEN USED ON DEEP WELL PUMP
BOTH SIDES
DIA. THRU 2 HOLES IN LINE
BLEND RAD.
1½ DIA. BOSS TYP.
DIA. THRU
START TAPER TO 1" DIA. ON HANDLE
BLEND TO SECTION B-B
START BLEND TO ROUND
1" DIA.
SECTION A-A
SECTION B-B
SECTION C-C
NOTES
1. DRAFT ANGLES TO BE 1½° TO 4°
2. ALL FILLETS & RADII TO BE ⅛" R. UNLESS OTHERWISE SPECIFIED
PARTS LIST
APPLICATION
2001
2002
DO NOT SCALE DRAWING
CAST IRON
Battelle
HANDLE
E
79986
2008
G 1320-1



FIND NO.	QTY.	PART NO. OR IDENTIFYING NO.	DWG. SIZE	DESCRIPTION	SPECIFICATION	NOTE NO.
4	1	2020	B	PLUNGER FOLLOWER SINGLE CUP		
3	1	2019	A	THREE INCH CUP		
2	1	2018	A	PLUNGER POPPET		
1	1	2017	B	PLUNGER CAGE		

PARTS LIST

REVISIONS

ZONE	LTR	DESCRIPTION	DATE	APPROVED

APPLICATION

THIS ITEM IS USED ON ASSEMBLIES

DRAWING NO.	PER ASSY	NO. OF ASSYS	TOTAL
2001	1	1	1

TO MAKE FINAL ASSEMBLY — TOTAL REQ'D.

DO NOT SCALE DRAWING

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES. TOLERANCES ARE:

.XX = .XXXX =
.XXX= ANGLES=

MATERIAL & TREATMENT

SIGNATURE	DIV.	DATE
DRAWN BY	659	1-5-78
DRAFTING APPD.		
DESIGN APPD.		
APPD.		
PROJECT APPD.		
SPECIAL APPD.		

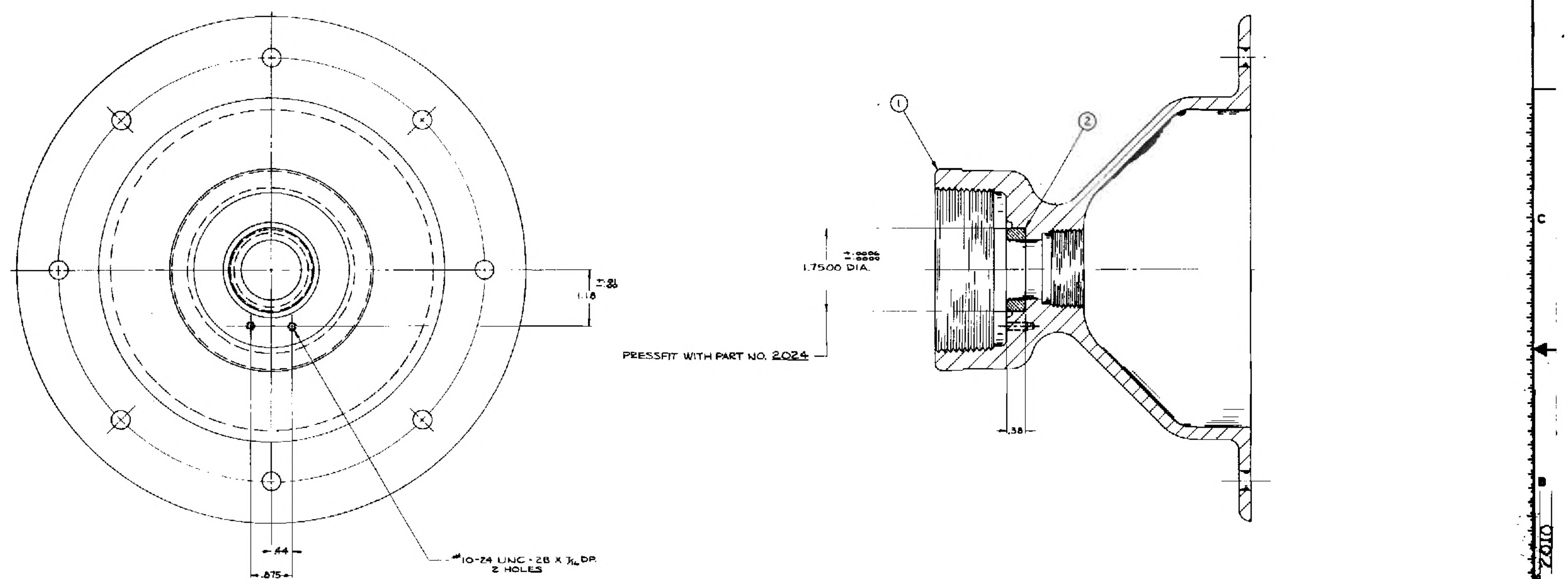
Battelle
Columbus Laboratories
505 King Avenue
Columbus, Ohio 43201
Telephone (614) 299-3151

TITLE THREE INCH PLUNGER ASSY. SINGLE CUP

SIZE	CODE IDENT. NO.	DIV. NO.	DWG. NO.	REV.
B	79986	644	2009	

SCALE 1" = 1" ACCT. G1320-1 SHEET 1 OF 1

CAT. 204166 FORM D-7 12-73



FIND NO.	QTY.	PART NO. OR IDENTIFYING NO.	DWG. SIZE	DESCRIPTION	SPECIFICATION
2	1	2024	A	BRASS VALVE SEAT	
1	1	2023	D	PUMP STAND	

PARTS LIST

APPLICATION			
THIS ITEM IS USED ON ASSEMBLIES			
DRAWING NO.	PER ASSY	NO. OF ASSYS	TOTAL
2001	1	1	1
TO MAKE FINAL ASSEMBLY			TOTAL REQ'D.

DO NOT SCALE DRAWING

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES. TOLERANCES ARE:

.XX = ±.01

.XXX = ±.005 ANGLES =

MATERIAL AND TREATMENT

SIGNATURE	DIV.	DATE
DRAWN BY		1-18-78
DRAFTING APPD.		
DESIGN APPD.		
APPD.		
APPD.		
PROJECT APPD.		
SPECIAL APPD.		

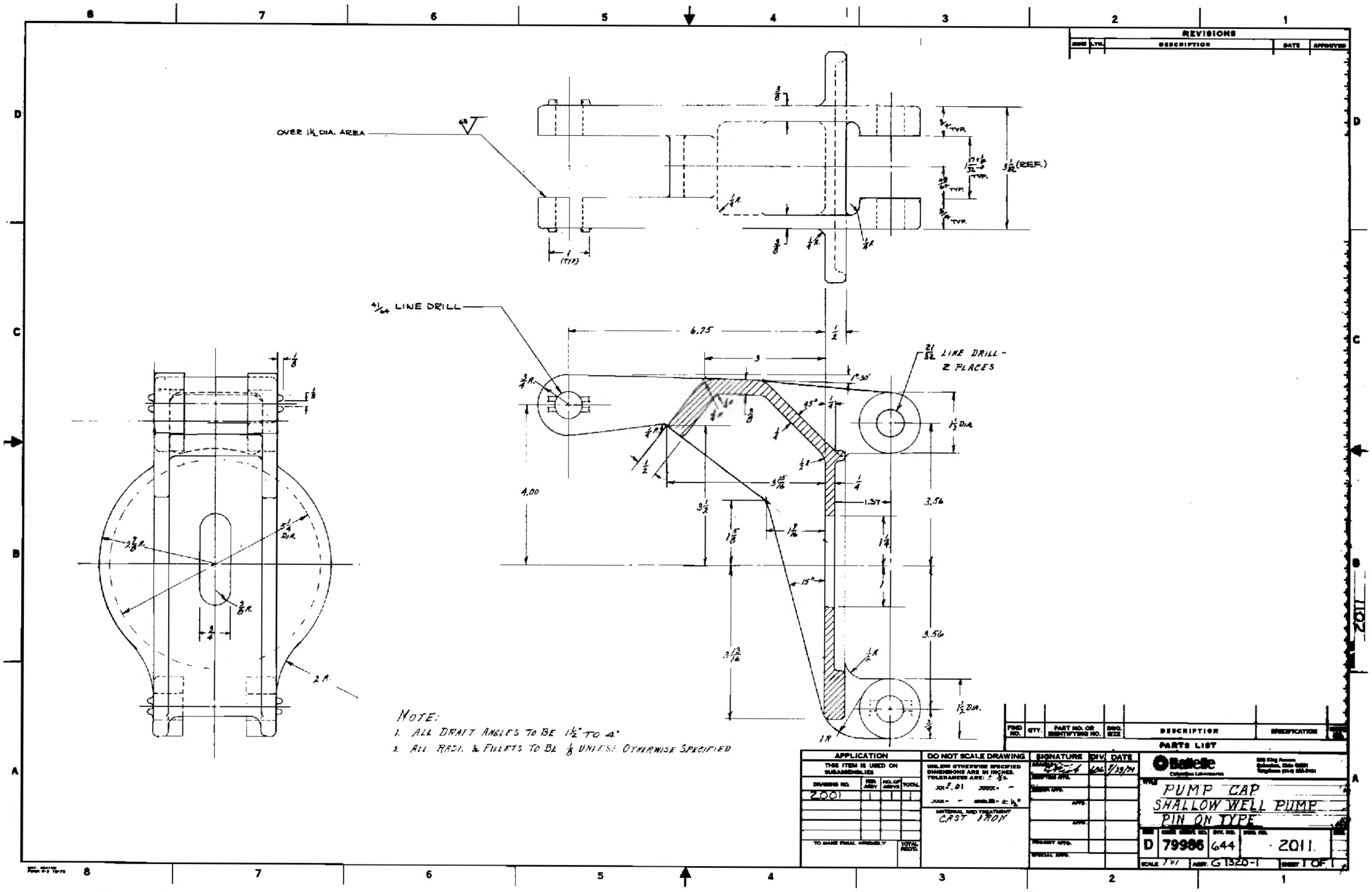
Battelle
Columbus Laboratories

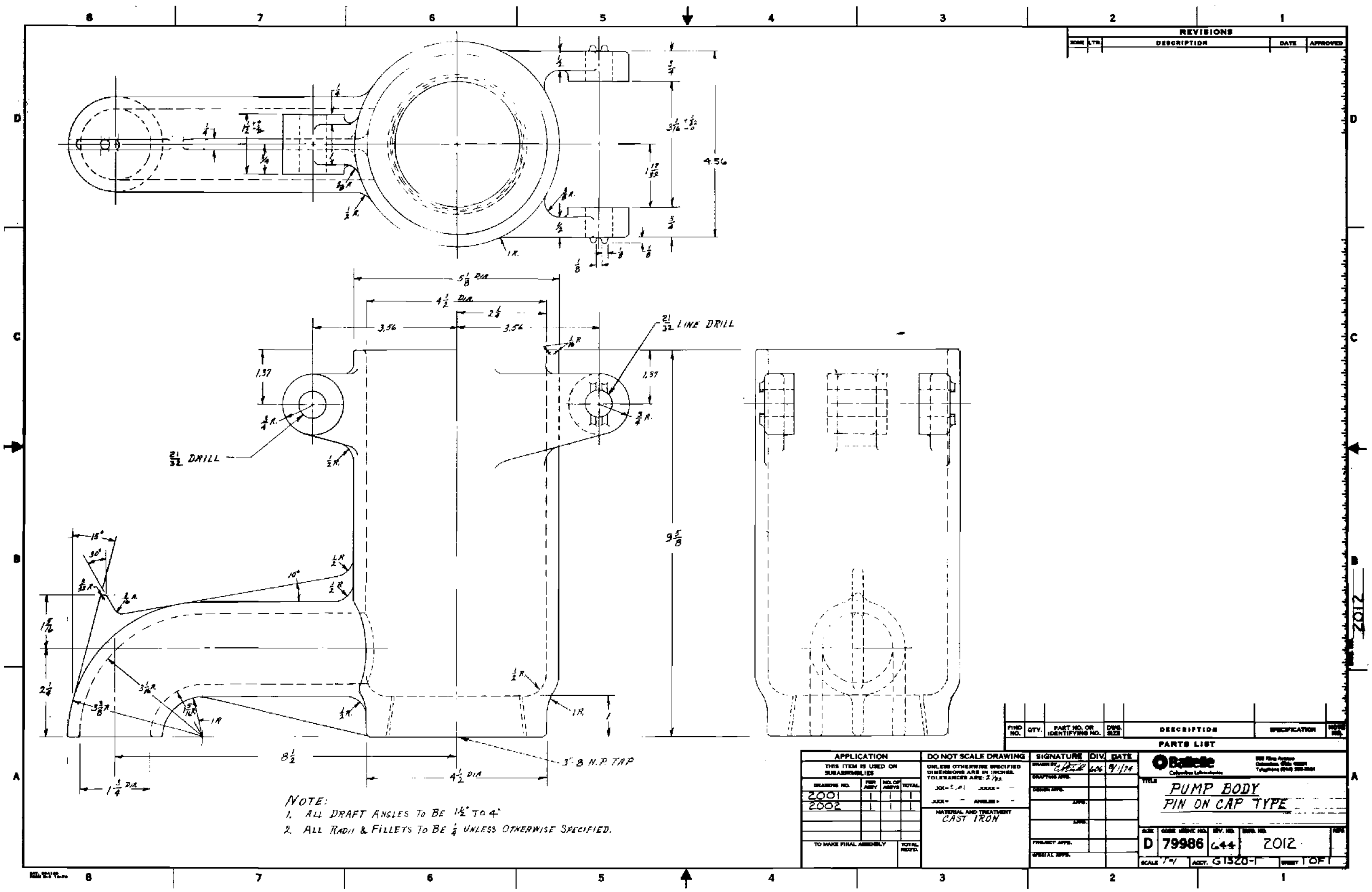
TITLE

PUMP STAND ASSY.

SIZE	CODE IDENT. NO.	DIV. NO.	DWG. NO.
D	79986	644	2010

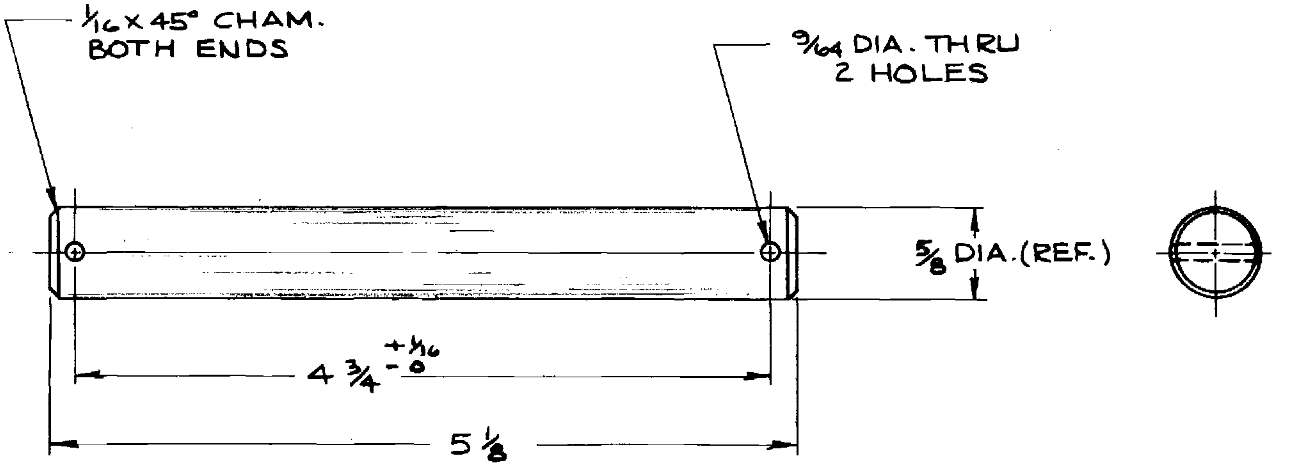
SCALE 1"=1" ACCT. G1320-1 SHEET 1 OF 1


REVISIONS
DESCRIPTION
DATE
APPROVED
OVER 1¼ DIA. AREA
LINE DRILL
6.75
3
21/32 LINE DRILL - 2 PLACES
1½ DIA.
4.00
3.56
3.56
1.37
15°
2 R.
1R
NOTE:
1. ALL DRAFT ANGLES TO BE 1½° TO 4°
2. ALL RADII & FILLETS TO BE ⅛ UNLESS OTHERWISE SPECIFIED
DESCRIPTION
SPECIFICATION
PARTS LIST
APPLICATION
THIS ITEM IS USED ON SUBASSEMBLIES
DRAWING NO.
2001
TO MAKE FINAL ASSEMBLY
TOTAL REQ'D.
DO NOT SCALE DRAWING
UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES. TOLERANCES ARE:
MATERIAL AND TREATMENT
CAST IRON
SIGNATURE
DIV.
DATE
Battelle
Columbus Laboratories
PUMP CAP
SHALLOW WELL PUMP
PIN ON TYPE
D
79986
644
2011
G 1320-1
1 OF 1



REVISIONS
ZONE | LTR. | DESCRIPTION | DATE | APPROVED
4.56
9 5/8
5 5/8 DIA
4 1/2 DIA
2 1/4
3.56
1.37
21/32 LINE DRILL
21/32 DRILL
8 1/2
4 1/2 DIA
1 3/4 DIA
3" 8 N.P. TAP
NOTE:
1. ALL DRAFT ANGLES TO BE 1 1/2° TO 4°
2. ALL RADII & FILLETS TO BE 1/4 UNLESS OTHERWISE SPECIFIED.
FIND NO. | QTY. | PART NO. OR IDENTIFYING NO. | DWG. SIZE | DESCRIPTION | SPECIFICATION | NOTE NO.
PARTS LIST
APPLICATION
THIS ITEM IS USED ON SUBASSEMBLIES
DRAWING NO. | PER ASSY | NO. OF ASSYS | TOTAL
2001 | 1 | 1 | 1
2002 | 1 | 1 | 1
TO MAKE FINAL ASSEMBLY
TOTAL REQ'D.
DO NOT SCALE DRAWING
UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES. TOLERANCES ARE: 1/32
MATERIAL AND TREATMENT
CAST IRON
SIGNATURE | DIV. | DATE
8/1/74
DRAFTING APPR.
DESIGN APPR.
PROJECT APPR.
SPECIAL APPR.
Battelle
Columbus Laboratories
TITLE
PUMP BODY
PIN ON CAP TYPE
SIZE D
79986
644
DWG. NO. 2012
SCALE 1=1
ACCT. G1320-1
SHEET 1 OF 1
2012

REVISIONS			
LTR	DESCRIPTION	DATE	APPROVED



APPLICATION			
THIS ITEM IS USED ON SUBASSEMBLIES			
DRAWING NO.	PER ASSY	NO. OF ASSYS	TOTAL
2001 "B"	1	1	1
2002 "A"	1	1	1
2002 "B"	2	1	2
TO MAKE FINAL ASSEMBLY			TOTAL REQ'D.

DO NOT SCALE DRAWING

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES. TOLERANCES ARE: ± 1/32
.XX = .XXXX = —
.XXX = — ANGLES = ± 1/2°

MATERIAL & TREATMENT
5/8 C.R.S. ROUND

SIGNATURE	DIV.	DATE
DRAWN BY [illegible]	659	1-7-75
DRAFTING APPD.		
DESIGN APPD.		
APPD.		
PROJECT APPD.		
SPECIAL APPD.		

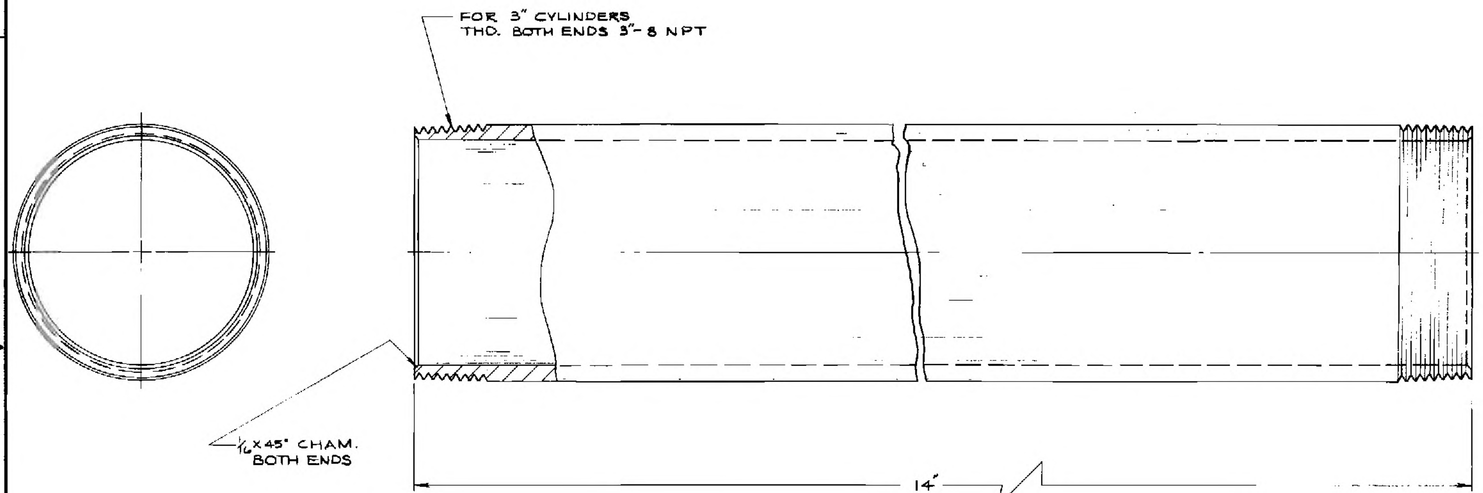
BATTELLE MEMORIAL INSTITUTE
COLUMBUS LABORATORIES
505 KING AVE., COLUMBUS, OHIO 43201

TITLE
ROD PIVOT PIN

SIZE	CODE IDENT. NO.	DIV. NO.	DWG. NO.	REV.
A	79986	644	2013	

SCALE 1" = 1" ACCT. G 1320-1 SHEET 1 OF 1

CAT. 294163 FORM D-5 5-70



NOTE:

PIPE MAY BE MADE OF EITHER OF THE FOLLOWING MATERIALS FOR 3" CYLINDERS.

*1ST OPTION - STD. P.V.C. 1120 PLASTIC PIPE (SCH. 40)

2ND OPTION - STD. BLACK STEEL PIPE (SCH. 40) COATED WITH .004 $^{+.004}_{-.000}$ THICKNESS OF SYNTHETASINE 200 (STONER-MUDGE) OR EQUIVALENT, ON ENTIRE SURFACE

3RD OPTION - STD. BLACK STEEL PIPE (SCH. 40) COATED WITH 2 COATS OF SOVAPON HI-BUILD EPOXY (MOBILE CHEMICAL CO.) OR EQUIVALENT OVER PRIMER

* PVC PIPE NOT TO BE USED IN SHALLOW WELL PUMP ASS'Y.

REVISIONS

ZONE	LTR.	DESCRIPTION	DATE	APPROVED

PARTS LIST

FIND NO.	QTY.	PART NO. OR IDENTIFYING NO.	DWG. SIZE	DESCRIPTION	SPECIFICATION	NOTE NO.

APPLICATION

THIS ITEM IS USED ON ASSEMBLIES

DRAWING NO.	PER ASSY	NO. OF ASSYS	TOTAL
2001	1	1	1
2002	1	1	1

TO MAKE FINAL ASSEMBLY — TOTAL REQ'D.

DO NOT SCALE DRAWING

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES. TOLERANCES ARE: ± 1/32

.XX = — .XXXX = —

.XXX = — ANGLES = —

MATERIAL AND TREATMENT: NOTED

SIGNATURE	DIV.	DATE
DRAWN BY	659	1-14-74
DRAFTING APPD.		
DESIGN APPD.		
APPD.		
APPD.		
PROJECT APPD.		
SPECIAL APPD.		

Battelle
Columbus Laboratories
505 King Avenue
Columbus, Ohio 43201
Telephone (614) 299-3151

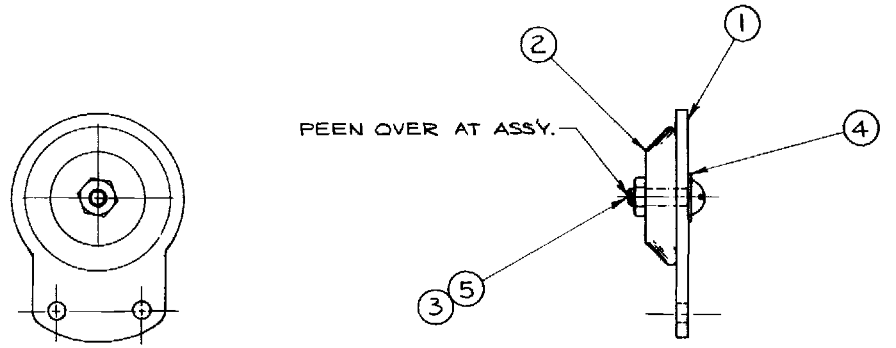
TITLE: PUMP CYLINDER

SIZE	CODE IDENT. NO.	DIV. NO.	DWG. NO.	REV.
C	79986	644	2014	

SCALE 1" = 1" ACCT. G1320-1 SHEET 1 OF 1

DWG. NO. 2014

CAT. 204197 FORM D-8 12-73



FIND NO.	QTY.	PART NO. OR IDENTIFYING NO.	DWG. SIZE	DESCRIPTION	SPECIFICATION	NOTE NO.
5	1	–	–	#10 NC-2B HEX NUT	BRASS	
4	1	–	–	#10 PLAIN FLAT WASHER	BRASS	
3	1	–	–	#10-24 NC-2A X 3/4 LONG RD. HD. SCR.	BRASS	
2	1	2022	A	CHECK VALVE WEIGHT		
1	1	2021	B	VALVE FLAPPER		

PARTS LIST

REVISIONS

ZONE	LTR	DESCRIPTION	DATE	APPROVED

APPLICATION

THIS ITEM IS USED ON ASSEMBLIES

DRAWING NO.	PER ASSY	NO. OF ASSYS	TOTAL
2001	1	1	1
2002	1	1	1

TO MAKE FINAL ASSEMBLY | TOTAL REQ'D.

DO NOT SCALE DRAWING

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES. TOLERANCES ARE:

.XX = .XXXX =
.XXX= ANGLES=

MATERIAL & TREATMENT

SIGNATURE	DIV.	DATE
DRAWN BY	659	1-9-75
DRAFTING APPD.		
DESIGN APPD.		
APPD.		
PROJECT APPD.		
SPECIAL APPD.		

Battelle Columbus Laboratories
505 King Avenue
Columbus, Ohio 43201
Telephone (614) 299-3151

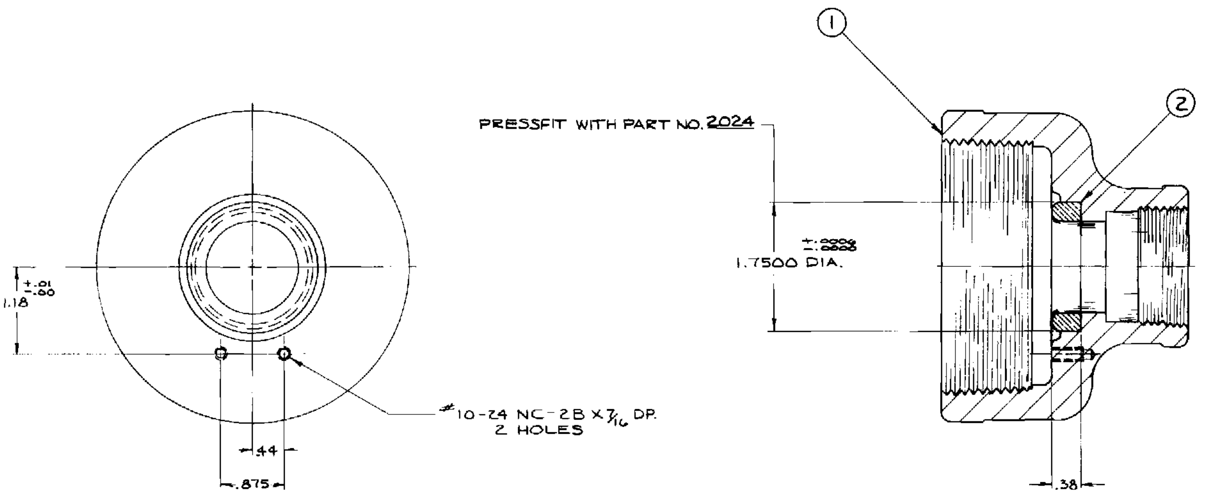
TITLE

CHECK VALVE ASS'Y.

SIZE	CODE IDENT. NO.	DIV. NO.	DWG. NO.	REV.
B	79986	644	2015	

SCALE 1" = 1" ACCT. SHEET 1 OF 1

CAT. 884166 FORM D-7 12-73



REVISIONS

ZONE	LTR.	DESCRIPTION	DATE	APPROVED

DWG. NO. 2016

FIND NO.	QTY.	PART NO. OR IDENTIFYING NO.	DWG. SIZE	DESCRIPTION	SPECIFICATION	NOTE NO.
2	1	2024	A	BRASS VALVE SEAT		
1	1	2025	C	CYLINDER END CAP		

PARTS LIST

APPLICATION

THIS ITEM IS USED ON SUBASSEMBLIES

DRAWING NO.	PER ASSY	NO. OF ASSYS	TOTAL
2001	1	1	1
2002	1	1	1

TO MAKE FINAL ASSEMBLY — TOTAL REQ'D.

DO NOT SCALE DRAWING

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES. TOLERANCES ARE:

.XX = ±.01 .XXXX = –
.XXX = ±.005 ANGLES = –

MATERIAL AND TREATMENT

SIGNATURE	DIV.	DATE
DRAWN BY	655	1-14-75
DRAFTING APPD.		
DESIGN APPD.		
APPD.		
APPD.		
PROJECT APPD.		
SPECIAL APPD.		

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Columbus Laboratories
505 King Avenue
Columbus, Ohio 43201
Telephone (614) 299-3151

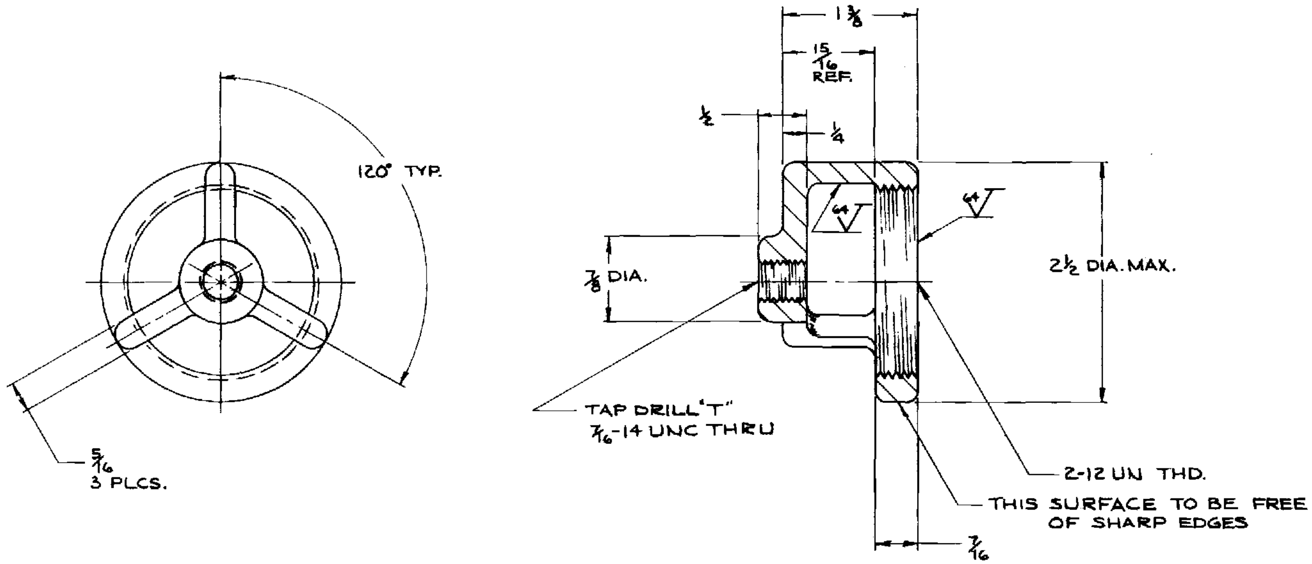
TITLE

LOWER VALVE HOUSING ASSY.

SIZE	CODE IDENT. NO.	DIV. NO.	DWG. NO.	REV.
C	79986	644	2016	

SCALE 1" = 1" ACCT. G1320-1 SHEET 1 OF 1

CAT. 894167 FORM D-8 10-73



NOTES:

1. ALL DRAFT ANGLES TO BE 1½° TO 4°
2. ALL FILLETS & RADII TO BE ⅛" R. UNLESS OTHERWISE SPECIFIED

FIND NO.	QTY.	PART NO. OR IDENTIFYING NO.	DWG. SIZE	DESCRIPTION	SPECIFICATION	NOTE NO.

PARTS LIST

APPLICATION			
THIS ITEM IS USED ON SUBASSEMBLIES			
DRAWING NO.	PER ASSY	NO. OF ASSYS	TOTAL
2030	1	1	1
2009	1	1	1
TO MAKE FINAL ASSEMBLY			TOTAL REQ'D.

DO NOT SCALE DRAWING

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES. TOLERANCES ARE: ± 1/32

.XX = – .XXXX = –

.XXX = – ANGLES = ± ½°

MATERIAL & TREATMENT: CAST IRON

SIGNATURE	DIV.	DATE
DRAWN BY [illegible]	659	1-9-73
DRAFTING APPD.		
DESIGN APPD.		
APPD.		
PROJECT APPD.		
SPECIAL APPD.		

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505 King Avenue
Columbus, Ohio 43201
Telephone (614) 299-3151

TITLE: PLUNGER CAGE

SIZE	CODE IDENT. NO.	DIV. NO.	DWG. NO.	REV.
B	79986	644	2017	

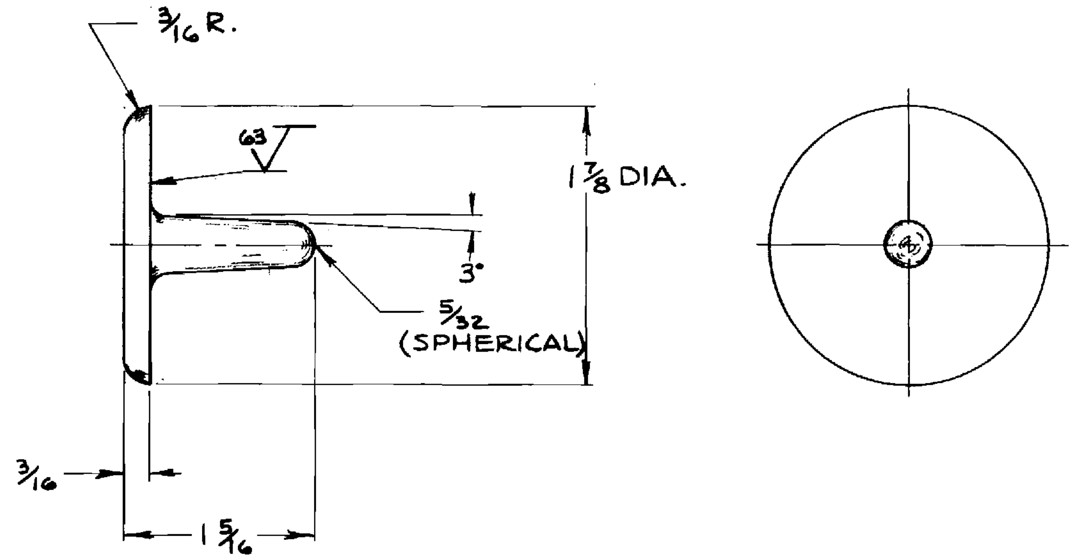
SCALE 1" = 1" ACCT. G1320-1 SHEET 1 OF 1

CAT. 294168 FORM D-7 12-73

NOTES:

1. ALL DRAFT ANGLES TO BE 1½° TO 4°
2. ALL FILLETS & RADII TO BE ⅛" R. UNLESS OTHERWISE SPECIFIED

REVISIONS			
LTR	DESCRIPTION	DATE	APPROVED



APPLICATION			
THIS ITEM IS USED ON SUBASSEMBLIES			
DRAWING NO.	PER ASSY	NO. OF ASSYS	TOTAL
2030	1	1	1
2009	1	1	1
TO MAKE FINAL ASSEMBLY			TOTAL REQ'D.

DO NOT SCALE DRAWING

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES. TOLERANCES ARE: ± 1/32

.XX = – .XXXX = –

.XXX = – ANGLES = ± ½°

MATERIAL & TREATMENT: CAST IRON

SIGNATURE	DIV.	DATE
DRAWN BY	659	1-7-78
DRAFTING APPD.		
DESIGN APPD.		
APPD.		
PROJECT APPD.		
SPECIAL APPD.		

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505 KING AVE., COLUMBUS, OHIO 43201

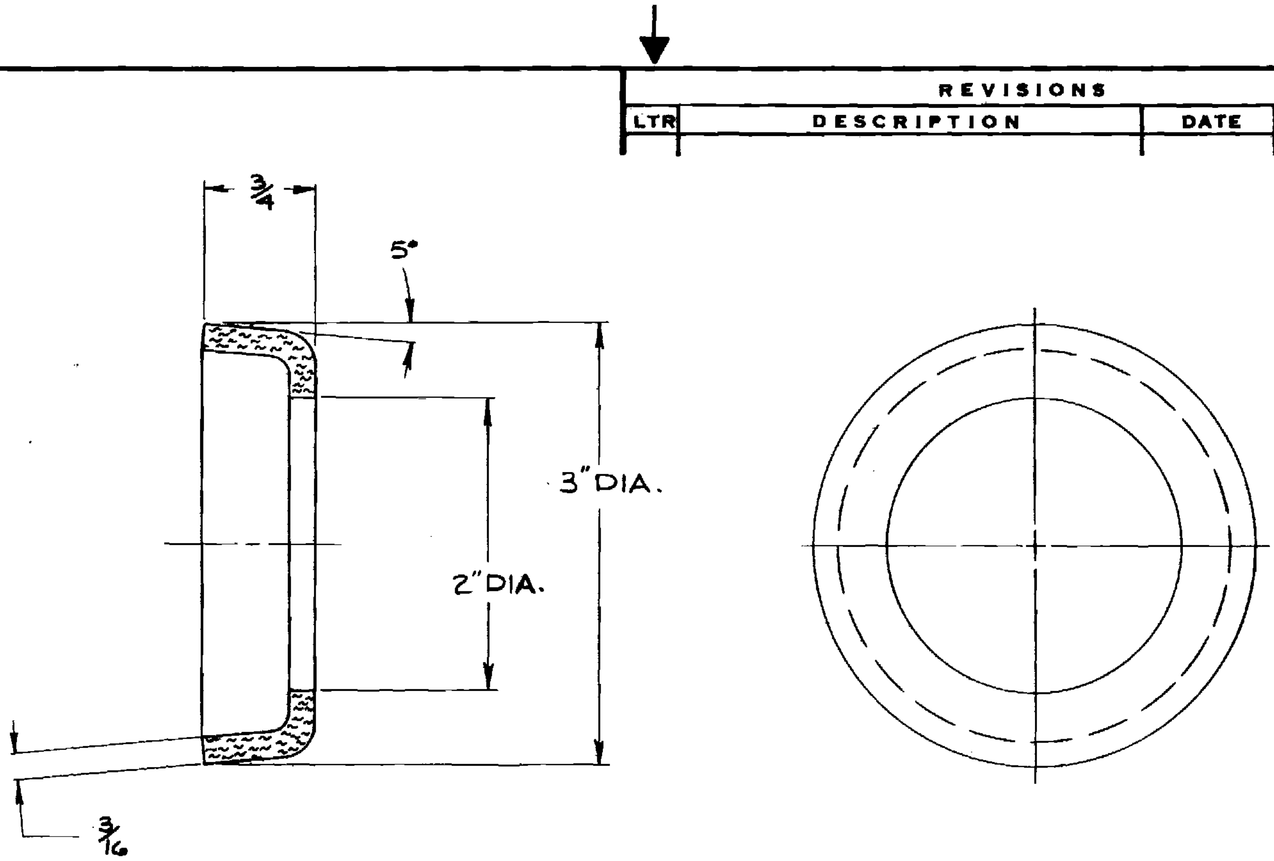
TITLE: PLUNGER POPPET

SIZE	CODE IDENT. NO.	DIV. NO.	DWG. NO.	REV.
A	79986	644	2018	

SCALE 1" = 1" ACCT. G1320-1 SHEET 1 OF 1

CAT. 294163 FORM D-5 5-70

REVISIONS			
LTR	DESCRIPTION	DATE	APPROVED



APPLICATION			
THIS ITEM IS USED ON SUBASSEMBLIES			
DRAWING NO.	PER ASSY	NO. OF ASSYS	TOTAL
2009	1	1	1
2030	1	1	1
TO MAKE FINAL ASSEMBLY			TOTAL REQ'D.

DO NOT SCALE DRAWING

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES. TOLERANCES ARE: ± 1/32

.XX = – .XXXX = –

.XXX = – ANGLES = ± 1°

MATERIAL & TREATMENT

LEATHER

SIGNATURE	DIV.	DATE
DRAWN BY dew	659	1-7-75
DRAFTING APPD.		
DESIGN APPD.		
APPD.		
PROJECT APPD.		
SPECIAL APPD.		

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COLUMBUS LABORATORIES
505 KING AVE., COLUMBUS, OHIO 43201

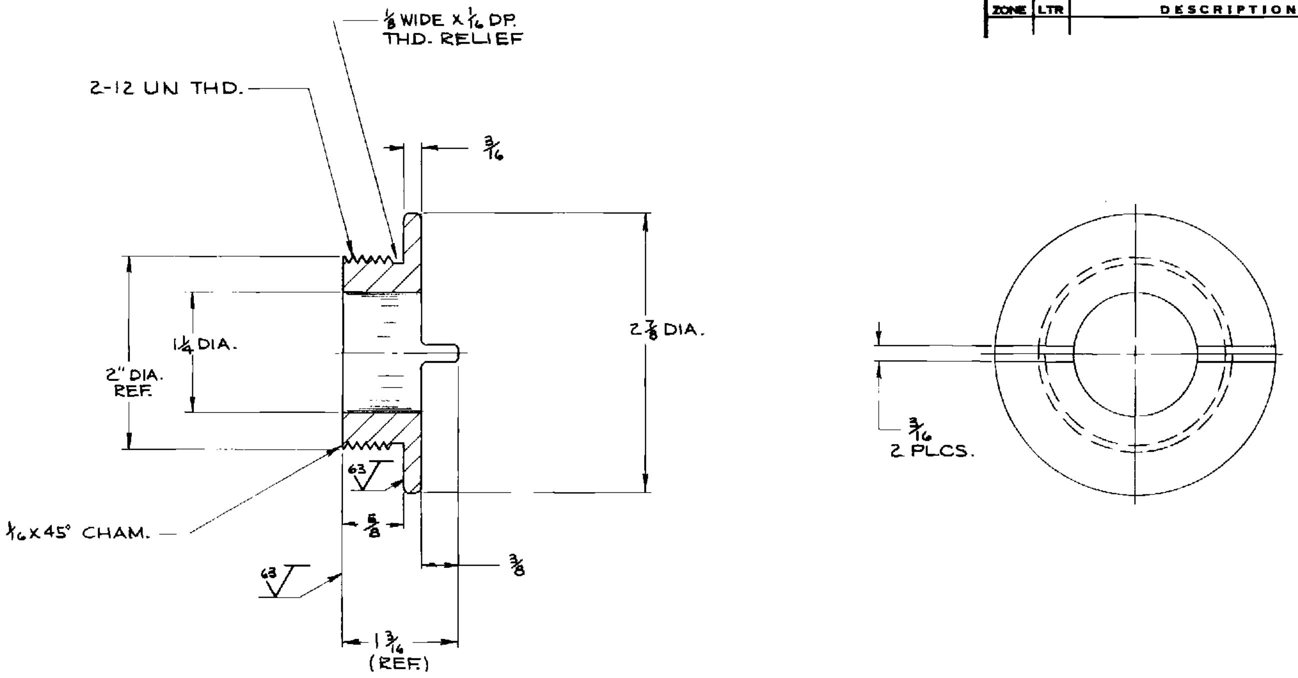
TITLE

THREE INCH CUP

SIZE	CODE IDENT. NO.	DIV. NO.	DWG. NO.	REV.
A	79986	644	2019	

SCALE 1" = 1" ACCT. G1320-1 SHEET 1 OF 1

CAT. 294163 FORM D-5 5-70



NOTES:
1. ALL DRAFT ANGLES TO BE 1½° TO 4°
2. ALL FILLETS & RADII TO BE 1/16" R. UNLESS OTHERWISE SPECIFIED

REVISIONS

ZONE	LTR	DESCRIPTION	DATE	APPROVED

PARTS LIST

FIND NO.	QTY.	PART NO. OR IDENTIFYING NO.	DWG. SIZE	DESCRIPTION	SPECIFICATION	NOTE NO.

APPLICATION			
THIS ITEM IS USED ON SUBASSEMBLIES			
DRAWING NO.	PER ASSY	NO. OF ASSYS	TOTAL
2009	1	1	1
TO MAKE FINAL ASSEMBLY			TOTAL REQ'D.

DO NOT SCALE DRAWING
UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES. TOLERANCES ARE: ± 1/32
.XX = – .XXXX = –
.XXX = – ANGLES = ± ½°

MATERIAL & TREATMENT
CAST IRON

SIGNATURE	DIV.	DATE
DRAWN BY	659	1-8-75
DRAFTING APPD.		
DESIGN APPD.		
APPD.		
PROJECT APPD.		
SPECIAL APPD.		

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505 King Avenue
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Telephone (614) 299-3151

TITLE PLUNGER FOLLOWER SINGLE CUP

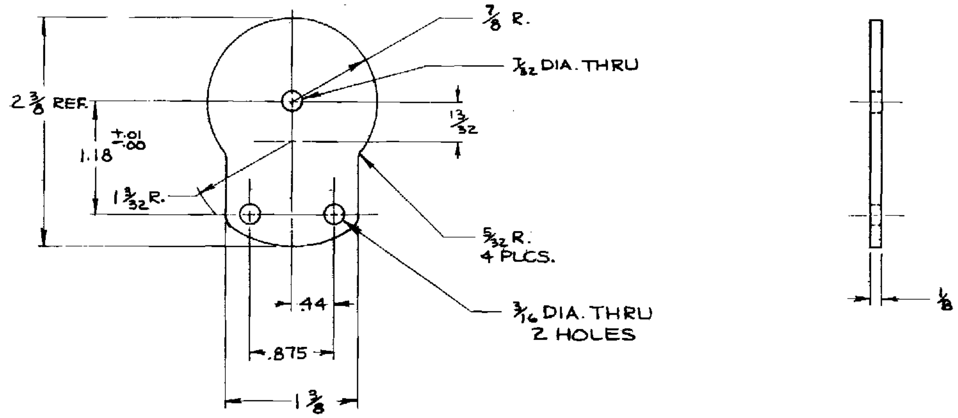
SIZE	CODE IDENT. NO.	DIV. NO.	DWG. NO.	REV.
B	79986	644	2020	

SCALE 1" = 1" ACCT. G 1320-1 SHEET 1 OF 1

CAT. 594196
FORM B-7 12-73

ZONE	LTR	DESCRIPTION	DATE	APPROVED

REVISIONS



FIND NO.	QTY.	PART NO. OR IDENTIFYING NO.	DWG. SIZE	DESCRIPTION	SPECIFICATION	NOTE NO.

PARTS LIST

APPLICATION			
THIS ITEM IS USED ON SUBASSEMBLIES			
DRAWING NO.	PER ASSY	NO. OF ASSYS	TOTAL
2015	1	1	1
TO MAKE FINAL ASSEMBLY			TOTAL REQ'D.

DO NOT SCALE DRAWING

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES. TOLERANCES ARE: ± 1/32

.XX = ±.01 .XXXX = —

.XXX = ±.005 ANGLES = —

MATERIAL & TREATMENT

LEATHER

SIGNATURE	DIV.	DATE
DRAWN BY	659	1-8-75
DRAFTING APPD.		
DESIGN APPD.		
APPD.		
PROJECT APPD.		
SPECIAL APPD.		

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505 King Avenue
Columbus, Ohio 43201
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TITLE

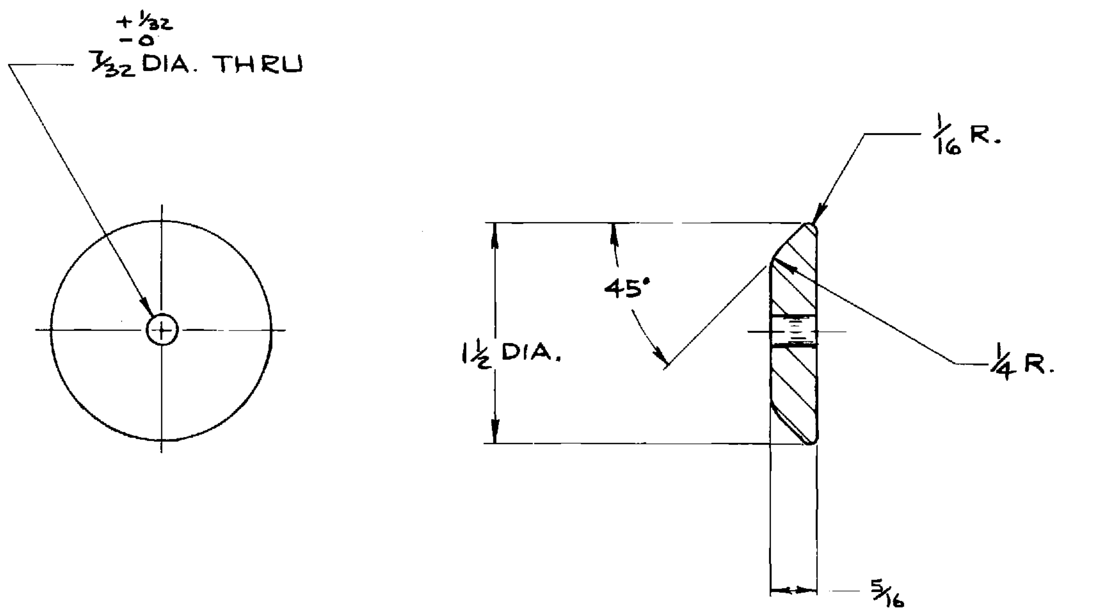
VALVE FLAPPER

SIZE	CODE IDENT. NO.	DIV. NO.	DWG. NO.	REV.
B	79986	644	2021	

SCALE 1" = 1" ACCT. G1320-1 SHEET 1 OF 1

CAT. 224166 FORM D-7 12-73

REVISIONS			
LTR	DESCRIPTION	DATE	APPROVED



APPLICATION			
THIS ITEM IS USED ON SUBASSEMBLIES			
DRAWING NO.	PER ASSY	NO. OF ASSYS	TOTAL
2015	1	1	1
TO MAKE FINAL ASSEMBLY			TOTAL REQ'D.

DO NOT SCALE DRAWING

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES. TOLERANCES ARE: 1/32

.XX = – .XXXX = –

.XXX = – ANGLES = ± 1/2°

MATERIAL & TREATMENT

CAST IRON

SIGNATURE	DIV.	DATE
DRAWN BY [signature]	659	1-8-75
DRAFTING APPD.		
DESIGN APPD.		
APPD.		
PROJECT APPD.		
SPECIAL APPD.		

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COLUMBUS LABORATORIES
505 KING AVE., COLUMBUS, OHIO 43201

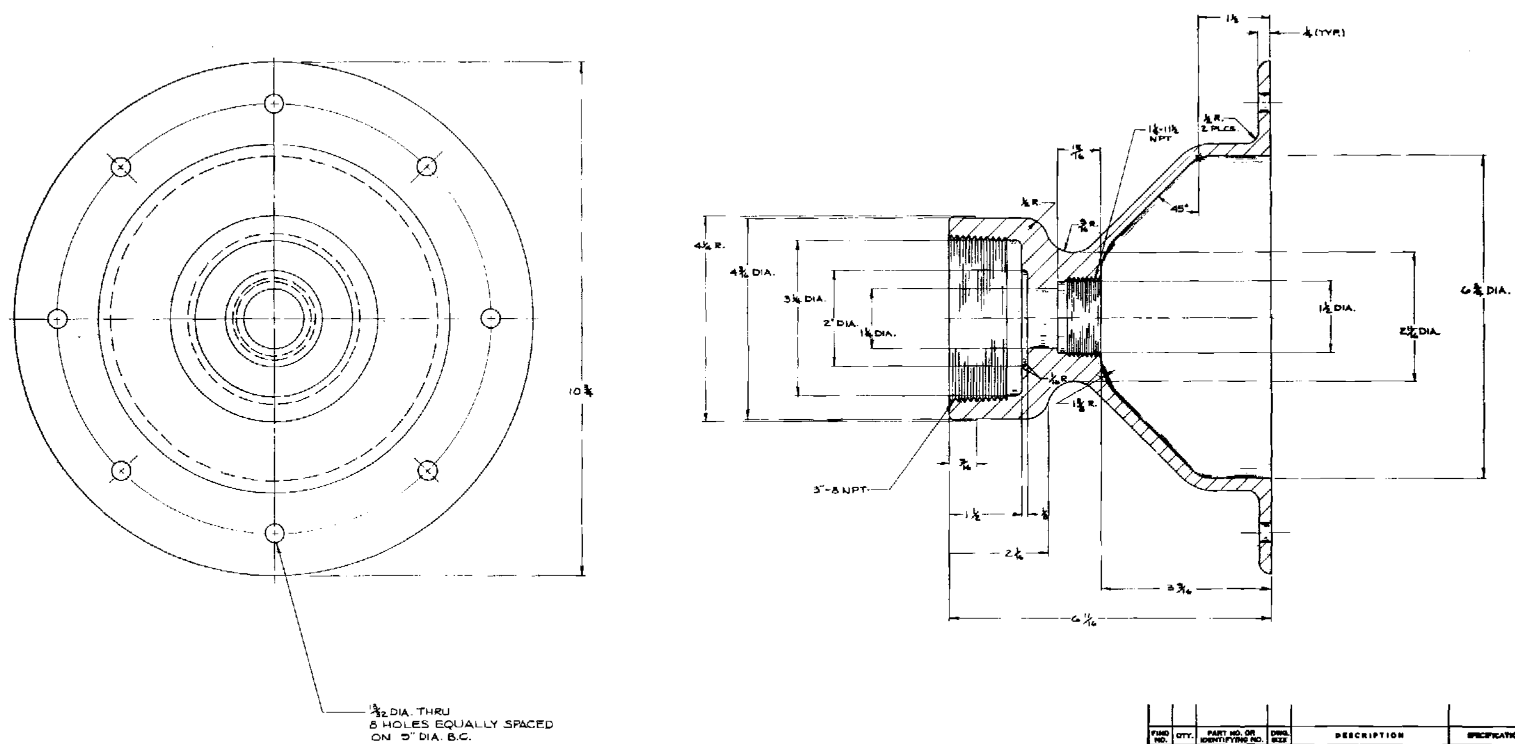
TITLE

CHECK VALVE WEIGHT

SIZE	CODE IDENT. NO.	DIV. NO.	DWG. NO.	REV.
A	79986	644	2022	

SCALE 1" = 1" ACCT G1320-1 SHEET 1 OF 1

CAT. 294163 FORM D-5 5-70



NOTES:
1. ALL DRAFT ANGLES TO BE 1½° TO 4°
2. ALL FILLETS & RADII TO BE ⅛" R. UNLESS OTHERWISE SPECIFIED
3. MOUNTING HOLES SHOWN HERE ARE FOR ⅜" BOLTS, BUT FLANGE IS WIDE ENOUGH FOR ½" BOLTS & WASHERS

REVISIONS

PARTS LIST

APPLICATION — THIS ITEM IS USED ON ASSEMBLIES

DRAWING NO.	PER ASSY	NO. OF ASSYS	TOTAL
2001	1	1	1
2002	1	1	1

DO NOT SCALE DRAWING
UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES. TOLERANCES ARE: ± 1/32
ANGLES = ± ½°

MATERIAL AND TREATMENT: CAST IRON

Battelle Columbus Laboratories

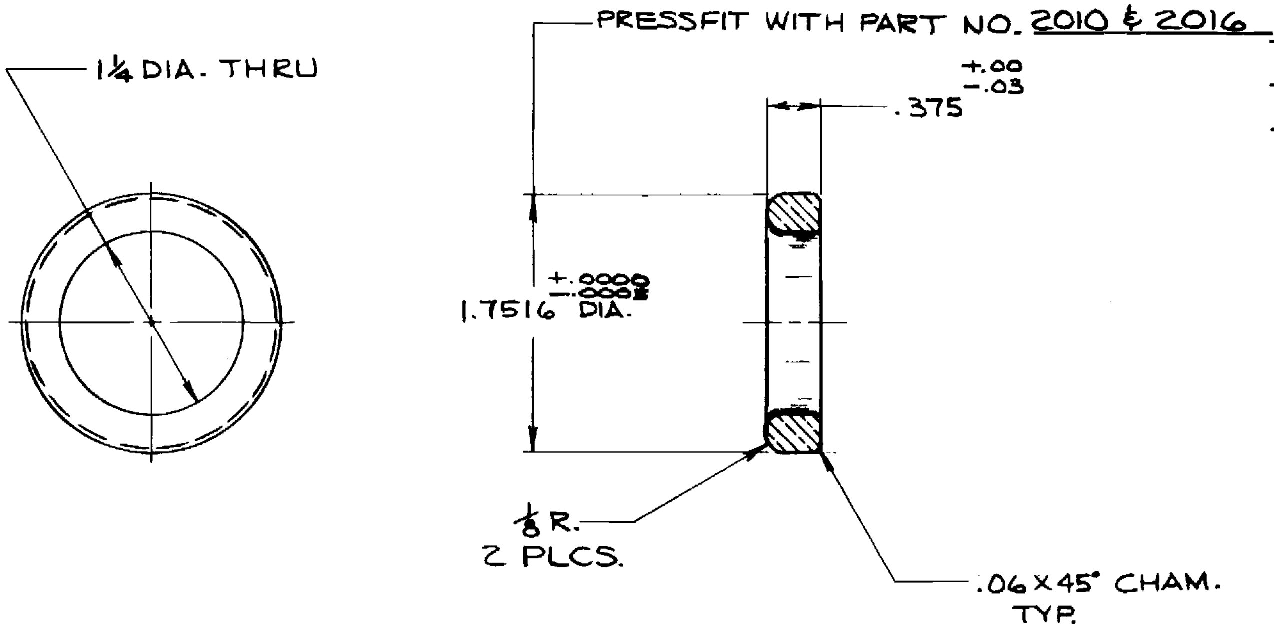
TITLE: PUMP STAND

SIZE	CODE IDENT. NO.	DIV. NO.	DWG. NO.
D	79986	644	2023

SCALE 1" = 1" ACCT. G1320-1 SHEET 1 OF 1

2023

REVISIONS			
LTR	DESCRIPTION	DATE	APPROVED



APPLICATION			
THIS ITEM IS USED ON SUBASSEMBLIES			
DRAWING NO.	PER ASSY	NO. OF ASSYS	TOTAL
2010	1	1	1
2016	1	1	1
TO MAKE FINAL ASSEMBLY			TOTAL REQ'D.

DO NOT SCALE DRAWING

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES. TOLERANCES ARE: ± 1/32
.XX = ±.01 .XXXX = –
.XXX = – ANGLES = ± ½°

MATERIAL & TREATMENT
BRASS

SIGNATURE	DIV.	DATE
DRAWN BY [illegible]	659	1-7-7[illegible]
DRAFTING APPD.		
DESIGN APPD.		
APPD.		
PROJECT APPD.		
SPECIAL APPD.		

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COLUMBUS LABORATORIES
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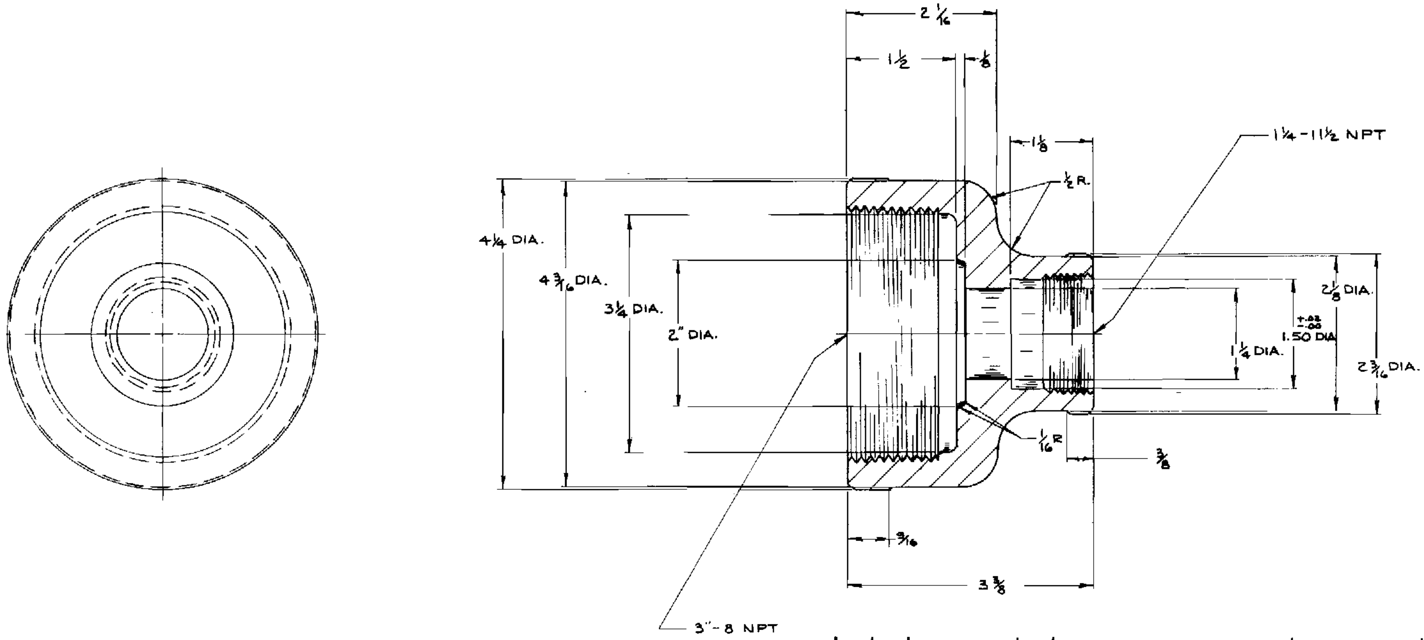
TITLE
BRASS
VALVE SEAT

SIZE	CODE IDENT. NO.	DIV. NO.	DWG. NO.	REV.
A	79986	644	2024	

SCALE 1" = 1" ACCT. G 1320-1 SHEET 1 OF 1

CAT. 294163 FORM D-5 5-70



NOTES:

1. ALL DRAFT ANGLES TO BE 1 1/2° TO 4°
2. ALL FILLETS & RADII TO BE 1/8" R. UNLESS OTHERWISE SPECIFIED

REVISIONS

ZONE	LTR.	DESCRIPTION	DATE	APPROVED

PARTS LIST

FIND NO.	QTY.	PART NO. OR IDENTIFYING NO.	DWG. SIZE	DESCRIPTION	SPECIFICATION	NOTE NO.

APPLICATION

THIS ITEM IS USED ON SUBASSEMBLIES

DRAWING NO.	PER ASSY	NO. OF ASSYS	TOTAL
2016	1	1	1
2002	1	1	1
2001"C"	1	1	1

TO MAKE FINAL ASSEMBLY — TOTAL REQ'D.

DO NOT SCALE DRAWING

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES. TOLERANCES ARE: ± 1/32

.XX = — .XXXX = —

.XXX = — ANGLES = ± 1/2°

MATERIAL AND TREATMENT: CAST IRON

SIGNATURE	DIV.	DATE
DRAWN BY —	659	1-10-78
DRAFTING APPD.		
DESIGN APPD.		
APPD.		
APPD.		
PROJECT APPD.		
SPECIAL APPD.		

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505 King Avenue
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TITLE: CYLINDER END CAP

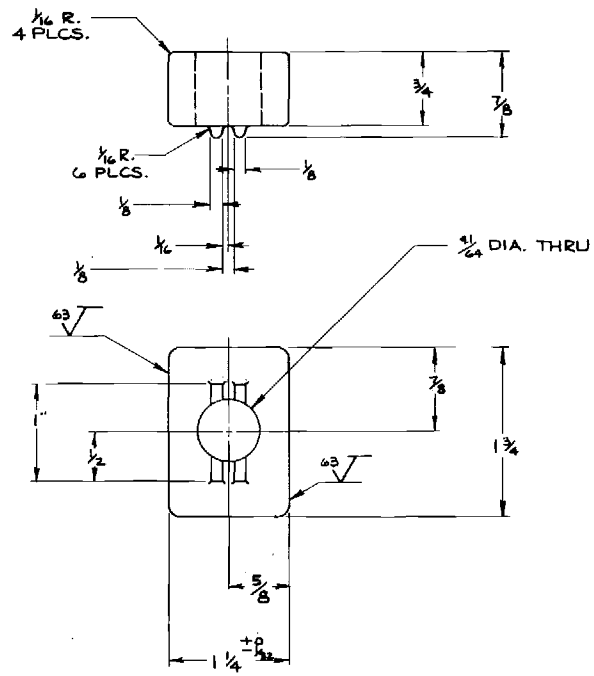
SIZE	CODE IDENT. NO.	DIV. NO.	DWG. NO.	REV.
C	79986	644	2025	

SCALE 1"=1" ACCT. G1320-1 SHEET 1 OF 1

DWG. NO. 2025

CAT. 294107 FORM 0-8 12-76

REVISIONS				
ZONE	LTR	DESCRIPTION	DATE	APPROVED



NOTES:

1. ALL DRAFT ANGLES TO BE 1½° TO 4°
2. ALL FILLETS & RADII TO BE 1/8" R. UNLESS OTHERWISE SPECIFIED

FIND NO.	QTY.	PART NO. OR IDENTIFYING NO.	DWG. SIZE	DESCRIPTION	SPECIFICATION	NOTE NO.

PARTS LIST

APPLICATION			
THIS ITEM IS USED ON SUBASSEMBLIES			
DRAWING NO.	PER ASSY	NO. OF ASSYS	TOTAL
2002	2	1	2
TO MAKE FINAL ASSEMBLY			TOTAL REQ'D.

DO NOT SCALE DRAWING

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES. TOLERANCES ARE: ± 1/64

.XX = – .XXXX = –
.XXX = – ANGLES = –

MATERIAL & TREATMENT: CAST IRON

SIGNATURE	DIV.	DATE
DRAWN BY	659	1-8-75
DRAFTING APPD.		
DESIGN APPD.		
APPD.		
PROJECT APPD.		
SPECIAL APPD.		

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Columbus, Ohio 43201
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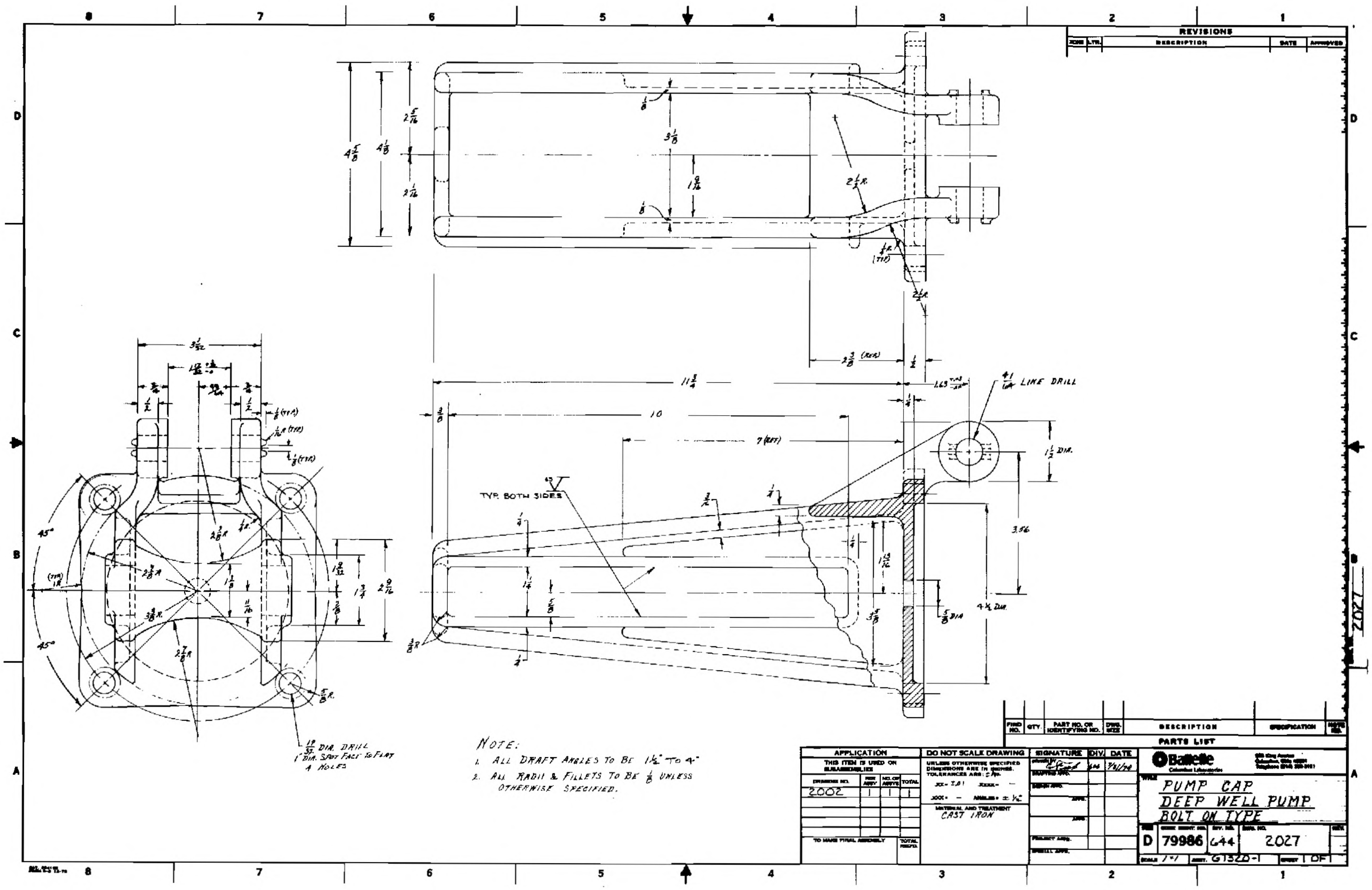
TITLE: SLIDING BLOCK

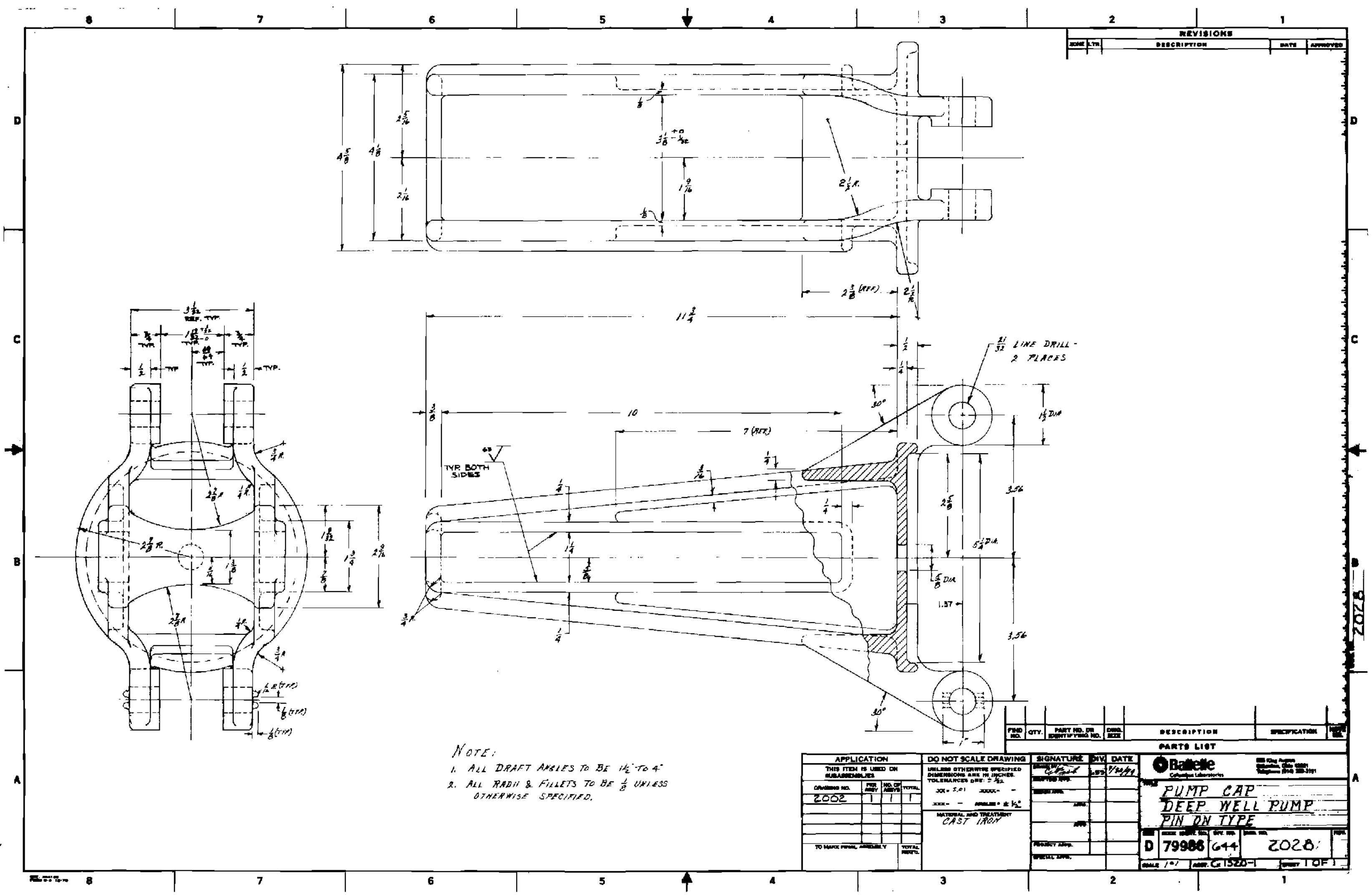
SIZE	CODE IDENT. NO.	DIV. NO.	DWG. NO.	REV.
B	79986	644	2026	

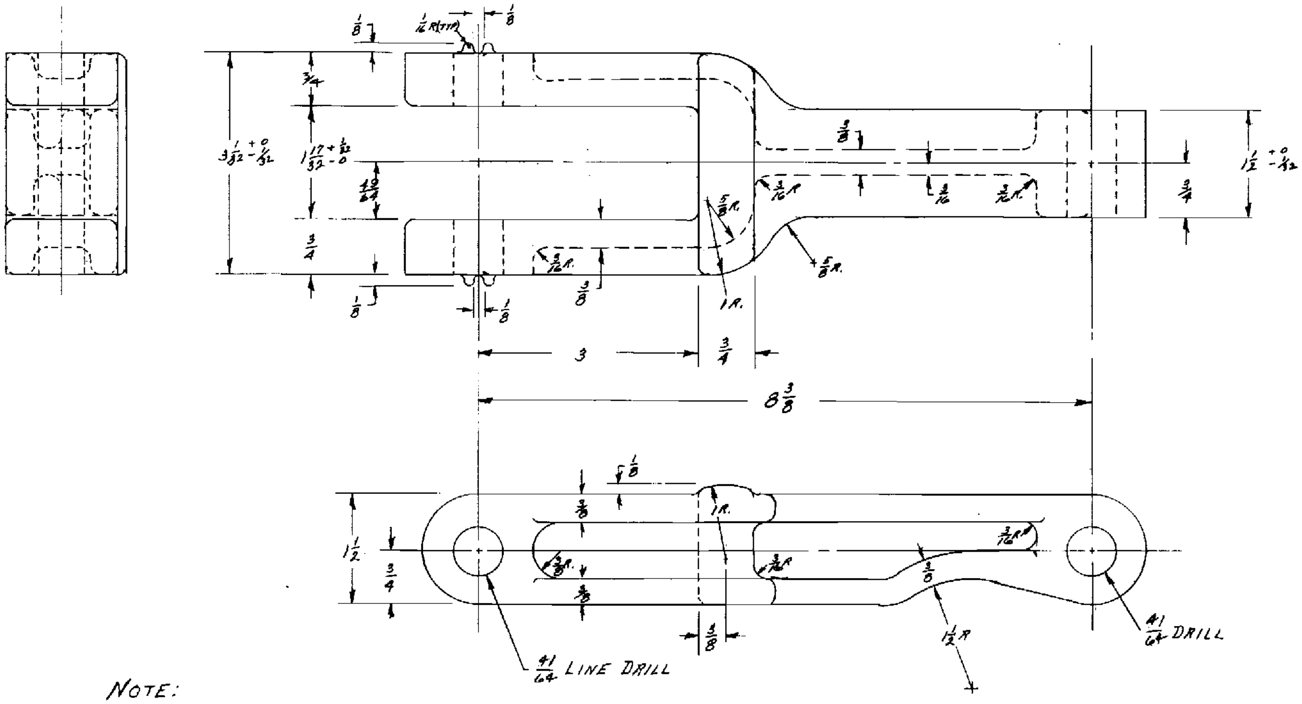
SCALE 1"=1" ACCT. G1320-1 SHEET 1 OF 1

CAT. 894186 FORM D-7 12-73



TYP. BOTH SIDES
LINE DRILL
19/32 DIA. DRILL
1" DIA. SPOT FACE TO FLAT
4 HOLES
NOTE:
1. ALL DRAFT ANGLES TO BE 1½° TO 4°
2. ALL RADII & FILLETS TO BE 1/8 UNLESS OTHERWISE SPECIFIED.
REVISIONS
DESCRIPTION
DATE
PARTS LIST
APPLICATION
THIS ITEM IS USED ON
2002
DO NOT SCALE DRAWING
UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES.
MATERIAL AND TREATMENT
CAST IRON
SIGNATURE
DIV.
DATE
7/31/74
TO MAKE FINAL ASSEMBLY
TOTAL
Battelle
Columbus Laboratories
PUMP CAP
DEEP WELL PUMP
BOLT ON TYPE
D
79986
644
2027
G1320-1


REVISIONS
ZONE
LTR
DESCRIPTION
DATE
APPROVED
11 3/4
10
7 (REF)
2 3/8 (REF)
21/32 LINE DRILL - 2 PLACES
1 1/2 DIA
5 1/4 DIA
5/8 DIA
3.56
1.57
30°
TYP. BOTH SIDES
NOTE:
1. ALL DRAFT ANGLES TO BE 1½° TO 4°
2. ALL RADII & FILLETS TO BE 1/8 UNLESS OTHERWISE SPECIFIED.
APPLICATION
THIS ITEM IS USED ON SUBASSEMBLIES
2002
TO MAKE FINAL ASSEMBLY
DO NOT SCALE DRAWING
UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES.
MATERIAL AND TREATMENT
CAST IRON
SIGNATURE
DATE
FIND NO.
QTY.
PART NO. OR IDENTIFYING NO.
DESCRIPTION
SPECIFICATION
PARTS LIST
Battelle
Columbus Laboratories
PUMP CAP
DEEP WELL PUMP
PIN ON TYPE
D
79986
2028
SHEET 1 OF 1
2028



NOTE:

1. ALL DRAFT ANGLES TO BE 1½° TO 4°
2. ALL RADII & FILLETS 1/8" UNLESS OTHERWISE SPECIFIED.

REVISIONS

ZONE	LTR.	DESCRIPTION	DATE	APPROVED

PARTS LIST

FIND NO.	QTY.	PART NO. OR IDENTIFYING NO.	DWG. SIZE	DESCRIPTION	SPECIFICATION	NOTE NO.

APPLICATION

THIS ITEM IS USED ON ASSEMBLIES

DRAWING NO.	PER ASSY	NO. OF ASSYS	TOTAL
2002	1	1	1

TO MAKE FINAL ASSEMBLY — TOTAL REQ'D.

DO NOT SCALE DRAWING

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES. TOLERANCES ARE: ± 1/32

MATERIAL AND TREATMENT: CAST IRON

SIGNATURE	DIV.	DATE
DRAWN BY [signature]	606	8/5/74
DRAFTING APPR.		
DESIGN APPR.		
APPD.		
APPD.		
PROJECT APPR.		
SPECIAL APPR.		

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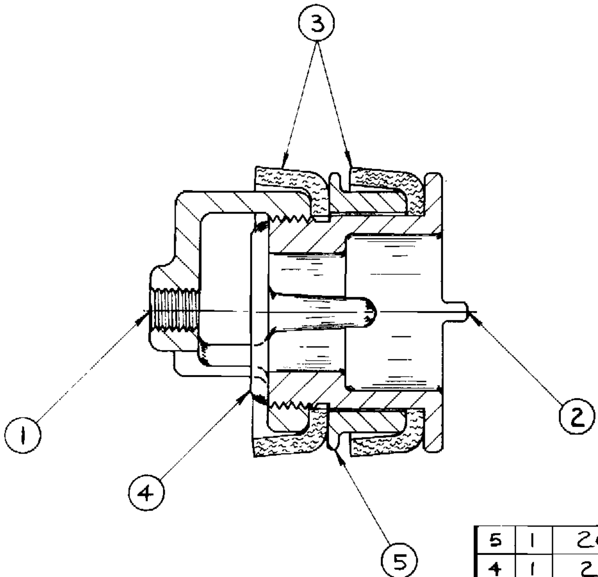
505 King Avenue
Columbus, Ohio 43201
Telephone (614) 299-3151

TITLE: HANDLE FULCRUM - DEEP WELL PUMP

SIZE	CODE IDENT. NO.	DIV. NO.	DWG. NO.	REV.
C	79986	644	2029	

SCALE 1=1 ACCT. G-2948-0001 SHEET 1 OF 1

CAT. 284187 FORM B-8 10-72



NOTE:

1. DOUBLE CUP PLUNGER TO BE USED WHEN WATER LEVEL IS MORE THAN 50 FT. BELOW SURFACE

FIND NO.	QTY.	PART NO. OR IDENTIFYING NO.	DWG. SIZE	DESCRIPTION	SPECIFICATION	NOTE NO.
5	1	2032	A	PLUNGER SPACER		
4	1	2018	A	PLUNGER POPPET		
3	2	2019	A	THREE INCH CUP		
2	1	2031	B	PLUNGER FOLLOWER		
1	1	2017	B	PLUNGER CAGE		

PARTS LIST

APPLICATION			
THIS ITEM IS USED ON ASSEMBLIES			
DRAWING NO.	PER ASSY	NO. OF ASSYS	TOTAL
2002	1	1	1
TO MAKE FINAL ASSEMBLY			TOTAL REQ'D.

DO NOT SCALE DRAWING

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES. TOLERANCES ARE:

.XX = .XXXX =

.XXX = ANGLES =

MATERIAL & TREATMENT

SIGNATURE	DIV.	DATE
DRAWN BY	655	1-10-76
DRAFTING APPD.		
DESIGN APPD.		
APPD.		
PROJECT APPD.		
SPECIAL APPD.		

Battelle Columbus Laboratories

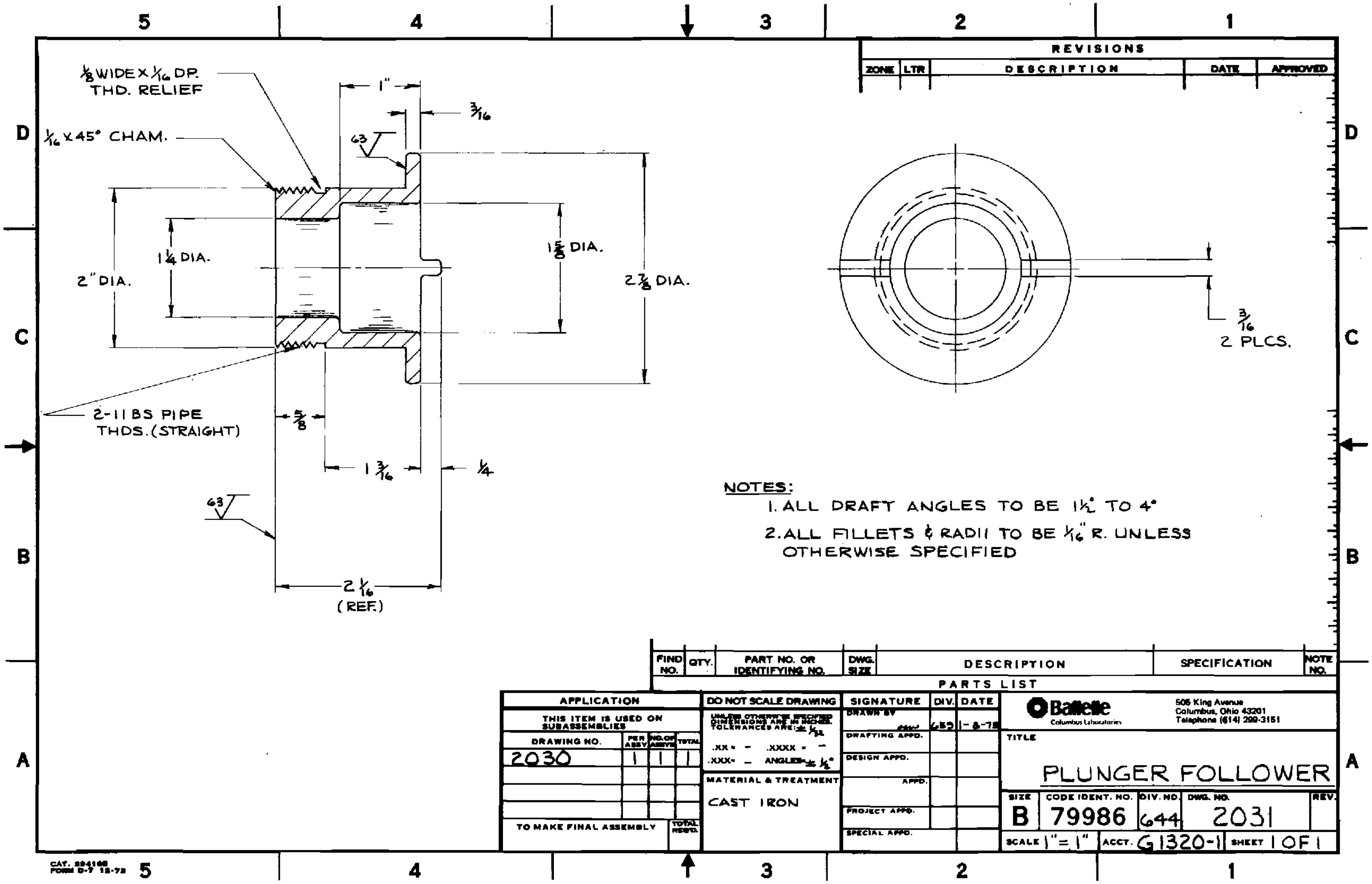
505 King Avenue
Columbus, Ohio 43201
Telephone (614) 299-3151

TITLE THREE INCH PLUNGER ASSY, DOUBLE CUP

SIZE	CODE IDENT. NO.	DIV. NO.	DWG. NO.	REV.
B	79986	644	2030	

SCALE 1" = 1" ACCT. SHEET 1 OF 1

CAT. 884168 FORM D-7 12-73



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Battelle
Columbus Laboratories
505 King Avenue
Columbus, Ohio 43201
Telephone (614) 299-3151
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NOTES:
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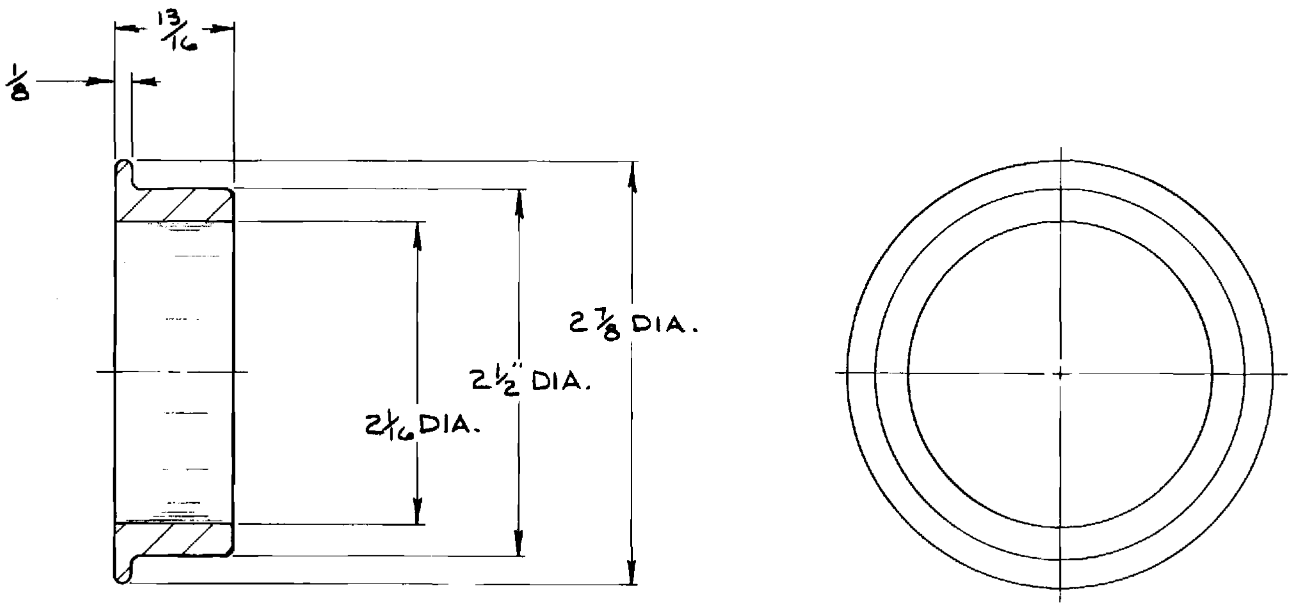

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BATTELLE MEMORIAL INSTITUTE
COLUMBUS LABORATORIES
505 KING AVE., COLUMBUS, OHIO 43201

TITLE
PLUNGER SPACER

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Project A-1894

FINAL REPORT ON THE UTILIZATION/ EVALUATION OF AN AID HAND-OPERATED WATER PUMP

Prepared for

The U.S. Agency for International Development
under Contract No. AID/ta-C-1354

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Atlanta, Georgia
January 1979

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Acknowledgments

This program of field testing the AID/Battelle hand-operated water pump would never have come into being without the help of many individuals who have supplied large quantities of factual information and have given freely of their time, permitting project personnel to profit from their seasoned judgment. This program did not contractually require active participation by local Agency for International Development Missions in Costa Rica and Nicaragua, but assistance was given abundantly in the form of personnel, vehicles, coordination of program activities, interest and insight into local conditions within each country. Personnel of the Ministries of Health in each country have contributed significantly with their own resources of vehicles, tools, and employees possessing noteworthy technical skills, dedication, and professionalism.

While it is impossible to list all individuals who have rendered assistance to the program, the authors of this report would like to acknowledge the following, with a special note of appreciation to Mr. Rene Uriza and Mr. José Zúniga in Nicaragua and Mr. Heriberto Rodriguez and Mr. Roberto Contreras in Costa Rica.

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Dr. Herman Weinstok, M.D., previous Minister of Health in Costa Rica

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Min. Adan Cajina Ríos, previous Minister of Health in Nicaragua

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Mr. Joseph J. Sconce, previous Mission Director, USAID/Costa Rica

Mr. Arthur W. Mudge, Mission Director, USAID/Nicaragua

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Mr. Heriberto Rodriguez, General Engineer, USAID/Costa Rica

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Mr. Roberto Contreras, Supervisor of Pump Programs, Ministry of Health in Costa Rica

Mr. W. K. (Tim) Journey, International Development Research Centre, Ottawa, Canada

Mr. Robert D. Fannon, Jr., of Battelle's Columbus Laboratories, also has been very helpful in supplying working drawings of the AID/Battelle pump and background information on the history of the pump.

The field testing program, it should be noted, has presented many unforeseeable problems. A severe drought occurred in both Costa Rica and Nicaragua in March, April, and May of 1977 that necessitated deepening many wells or switching to other sites before pumps could be installed. The same drought restricted the supply of hydroelectric power in Nicaragua to the point where the manufacturer was allowed only four hours per day of electricity to run his plant (and manufacture pumps). Further, civil disorder in Nicaragua during both the early months and the last months of 1978 somewhat restricted project personnel in that country from maintaining and monitoring the test pumps. Despite these delays the project remained basically on schedule. The required 12-month test-pump monitoring period in Nicaragua was completed prior to the civil disorders that are still continuing at the time of this writing, and the long-range effects of the disorders on the operational performance of the pumps are unknown.

Despite the many problems encountered during the life of the project, there have been many instances of overwhelming satisfaction. For example, at La Lamilla, Nicaragua, where a U.S.-manufactured Dempster pump was installed, community leaders have gone on record that "before the pump program was begun in the La Lamilla area, the infant mortality rate from diarrhea and vomiting was extremely high. Today, the infant mortality rate from these causes has practically disappeared, as have the symptoms." Such statements have made the problems, no matter how large, seem insignificant. The Georgia Institute

of Technology is grateful to the Agency for International Development, especially to Mr. James F. Thompson, Chief, Environmental Health Division, Office of Health, Development Support Bureau, U.S.A.I.D., Washington, D.C., for the opportunity of participating in such a program.

Summary

Recognizing the need in developing countries for a reliable supply of potable water and the corollary worldwide need for a long-lasting, low-cost, easily repaired, locally manufactured hand pump, the Agency for International Development (AID) began a series of contracts with the Battelle Memorial Institute to design and laboratory test a reciprocating shallow- and deep-well hand pump for LDC manufacture and use. A final design was developed and, in late 1976, AID contracted with the Office of International Programs at the Georgia Institute of Technology to evaluate the performance and acceptability of the AID pump in comparison with other pumps used in developing countries and the feasibility of local manufacture of the AID pumps. Cooperating with Georgia Tech on the project was the Central American Research Institute for Industry (ICAITI) and local Ministry of Health and AID officials in Costa Rica and Nicaragua.

Costa Rica

Costa Rica was chosen as a test country because of a sizable well and hand-pump loan that had been made to that country by AID and because of the country's need for an expanded water pump program. Provisions of the loan specifically included installation of water pumps on a large-scale basis, and it was felt that assistance in such areas as pump selection, installation techniques, and pump maintenance, as a part of this field-test program, would greatly benefit the government of Costa Rica. Costa Rican Ministry of Health and AID officials also strongly felt that a locally manufactured hand pump offered by the AID/Georgia Tech/ICAITI program had many advantages that should be included in the Costa Rican loan program (mainly employment generation, spare parts availability, and lower cost than for commercially available hand pumps).

Active work began in Costa Rica in January 1977, when AID/Washington and Georgia Tech jointly agreed that Costa Rica and Nicaragua should be the test countries for the program described herein. A machine shop that purchases rough iron castings from a local foundry was contracted to manufacture 20 AID pumps (eleven deep-well and nine shallow-well). These pumps were produced and delivered to a Ministry of Health warehouse for storage and installation in April 1977. Two different kinds of pumps were chosen with which to compare the

AID pump: a Dempster and a Japanese "Lucky" pump. Thirty-one sites, representative of Costa Rica, were chosen to receive the test pumps (16 AID pumps and 15 competitive pumps).

Wells were randomly tested by chemical and bacteriological analyses prior to test-pump installation and found to contain large numbers of intestinal bacteria, indicating that contamination was not being sealed off from the water. The pumps were installed by the Ministry of Health, the wells were disinfected with a chlorine-yielding compound and attempts were made to seal off the contamination sources. However, subsequent bacteriological testing has shown no improvement in the quality of the water due to poor construction of the upper well structures by the rural villagers, as well as their reluctance to accept an adequate amount of disinfection -- a matter that has caused great concern within the Ministry of Health. As a result, internal organizational changes have been made, and technicians and engineers are now being hired and trained in an attempt to alleviate the situation.

The prices of the AID pumps manufactured in Costa Rica were as follows:

Shallow-well	\$ 98 (each)
Deep-well	\$128 (each)
Patterns	\$498 (one-time charge only)

It should be noted that it has been very difficult during this program to arrive at a "representative" price for the AID pump because of extreme variances in manufacturing costs, especially overhead, between different countries and even between different manufacturers within the same country. For example, in Nicaragua, prior to placing an order with the manufacturer, price quotes were received from seven foundries that ranged from \$69 (shallow-well) and \$75 (deep-well) to \$225 (shallow-well) and \$250 (deep-well). During a trip to Ghana, the project director for this program discussed the AID pump with AID and Ghanaian government officials and discovered that prior investigations into the use of the AID pump for that country indicated a cost of approximately \$500 per pump (shallow-well or deep-well) for a relatively large order (100 pumps or more). Inquiries into the manufacture of the AID pump in the Dominican Republic have provided cost estimates ranging from \$160 (shallow-well) and \$200 (deep-well) to \$261 (shallow-well) and \$298 (deep-well), with the cost of patterns for making the castings included here in the price of the pumps, rather than as a separate cost.

To complicate matters even more, a judgment of expected quality must be balanced against the price of the pump and, in some cases, higher prices have not necessarily reflected a potential for the highest level of quality. However, various cost estimates show that the AID pump (shallow-well or deep-well) can be provided for an attractive price of below $100 (for instance, Indonesian foundries are manufacturing the deep-well pump for $60 and the shallow-well pump for $50 on orders of less than 50 pumps per order).

In general, the functional performance and acceptance of the Costa Rican-manufactured AID pump has been satisfactory, but serious casting defects were encountered which necessitated the replacement of five handles, two shallow-well caps, and one modified handle fulcrum. In all cases, these failures were caused by a lack of quality control at the foundry, which was not possible without laboratory facilities for testing the cast iron. The foundry used for the manufacture of the AID pumps in Costa Rica was representative of what might be found in many developing countries, but was not considered by project personnel to be the best in the country. Better foundries were available; however, these foundries were not interested in initial small orders even though the potential for much larger orders existed for the future.

Nicaragua

Nicaragua was chosen as a test country because of a rural water supply and hand-pump program loan by AID to that country involving the installation of hand-operated water pumps. The loan provisions included potable water systems that will construct 300-340 wells by the end of 1979. The AID/Georgia Tech/ICAITI program has complemented this program by providing technical assistance in pump selection, installation techniques, and pump maintenance, and has enabled the Ministry of Health in Nicaragua to take advantage of locally manufactured hand pumps that can be produced at a cost lower than commercially available pumps. This local program increases spare parts availability, reduces foreign exchange outflow, and stimulates local employment, as well as provides all other benefits of the AID pump mentioned in the introduction to this report.

As in Costa Rica, program activities began in Nicaragua in January 1977. A local foundry was chosen to manufacture 20 AID pumps (eleven deep-well and nine shallow-well), which were produced and delivered to a Ministry of Health warehouse for storage and installation in May. Two kinds of locally available pumps were chosen for comparison with the AID pump: a Dempster and a Brazilian "Marumby" pump. A pump developed by the International Development Research Centre (IDRC) of Ottawa, Canada, also was used for comparison. Thirty sites, representative of Nicaragua, were approved to receive the test pumps (16 AID pumps and 14 comparative pumps), and all of the sites required extensive preparatory work before pumps could be installed. Pumps were installed by a Ministry of Health installation team, and the wells were disinfected with a chlorine-yielding substance. As in Costa Rica, the sites had chemical and bacteriological testing prior to installation of test pumps and showed excessive amounts of intestinal bacteria.

In manufacturing the AID pumps in Nicaragua, a somewhat surprising situation was encountered -- foundries were plentiful, but pattern makers, a very necessary requirement for local production, were almost nonexistent. A foundry was located that appeared to have the resources, including pattern makers, to manufacture a quality AID pump, and a contract was signed for the manufacture of eleven deep-well pumps and nine shallow-well pumps. The prices of the pumps, for an order of 20, were as follows:

Shallow-well	$ 69 (each)
Deep-well	$ 75 (each)
Patterns	$1,000 (one-time charge only)

Two major maintenance problems with the AID pump became apparent when installation of the pumps began. The most critical problem was that the deep-well pump cap's weakest point was where maximum stress was being applied by the handle fulcrum upon the pivot arm of the cap, causing the pivot arm to break off from the cap. This problem was partly the fault of the design and partly the fault of the manufacturer. Because of an indented contour of the top plate of the pump body, it was not possible to cast the pump body as specified by the drawings (the patterns for the pump could not be removed from the molding sand without destroying the mold). Therefore, the manufacturer eliminated the indented contour of the top plate of the pump and then did not have enough clearance between the pivot arm of the cap and the top of the pump body. In order to obtain a better fit between the pump cap and the pump body, the manufacturer milled away a fillet on the pivot arm, thereby leaving a notch at the point of maximum stress. To alleviate the entire problem, the pump cap was redesigned by lifting the pivot arm up and away from the pump body and positioning it so that it does not absorb so much of the stress caused by the downward force of the pump handle. The redesigned cap was put into production at the manufacturer's foundry, installed on the pumps in the field, and has presented no additional problems.

The second major maintenance problem encountered with the AID pump in Nicaragua evolved when the manufacturer could not find 3-inch (inside diameter) PVC pipe for the deep-well cylinders. As a result, the manufacturer used 3-inch (outside diameter) PVC pipe and expanded it, by heating, to a 3-inch inside diameter. Quality control for such an approach was most difficult, and the results were unacceptable. While several of these PVC cylinders were installed in the field, it was decided that metal cylinders coated internally with epoxy (a Battelle option) would have to be used until the correct size PVC could be made available locally or imported from another country. In July (1978) the correct size PVC pipe was obtained from a local manufacturer and cylinders were produced according to specifications to be used for future pump installations.

Excessive wearing of leather cups has also presented problems for the AID pump in Nicaragua principally because of insufficiently smooth cylinders and oversized cups. Battelle drawings specify a 3-inch diameter leather cup for a 3-inch cylinder, which would be satisfactory if leather did not expand when wet. To allow for expansion, the dry cups should have been made approximately 1/16-inch undersized. A replacement order for the original oversized cups was filled by the pump manufacturer, and the wearing of these new cups has been considerably less due to the use of a blanking tool that improves the quality controls of the manufacturer.

Conclusions

Monitoring of pump performance has been concluded by Ministry of Health, AID, ICAITI, and Georgia Tech personnel. Despite many field test problems with the AID hand pump, field test results indicate that the AID pump can be manufactured with a high degree of quality in many less developed countries (LDCs). The test results, further, would most definitely encourage the manufacture, installation, and use of the AID hand pump in LDCs.

The AID pump can be manufactured in a developing country at a competitive, profitable price and at an acceptable level of quality if adequate facilities (foundries, pattern makers, machine shops and skilled machinists, raw materials, etc.) are available; however, the availability of adequate foundry facilities with acceptable pump prices and quality controls must be determined for each individual developing country. Public acceptance by rural villagers has been good, in terms of both aesthetics and ease of use by men, women and children. Further, the AID pump should have a positive impact in LDCs on the health of rural people, employment generation, and foreign exchange requirements. In addition, the demonstration of local capabilities for manufacturing a rather complicated product instead of importing it should enhance the national pride of the people.

While numerous manufacturing problems, especially quality control, have been encountered in both Costa Rica and Nicaragua, the majority of these problems have been such as to be expected when a product like the AID pump is introduced into LDC production for the first time. As subsequent orders are processed through the manufacturer's plant and as personnel become more familiar with the pump itself, quality control should be refined to the point where the orders are considered to be normal production. All manufacturing problems were satisfactorily overcome as a result of adaptation and modification designs which ultimately proved to be workable in the LDC environment.

INTRODUCTION

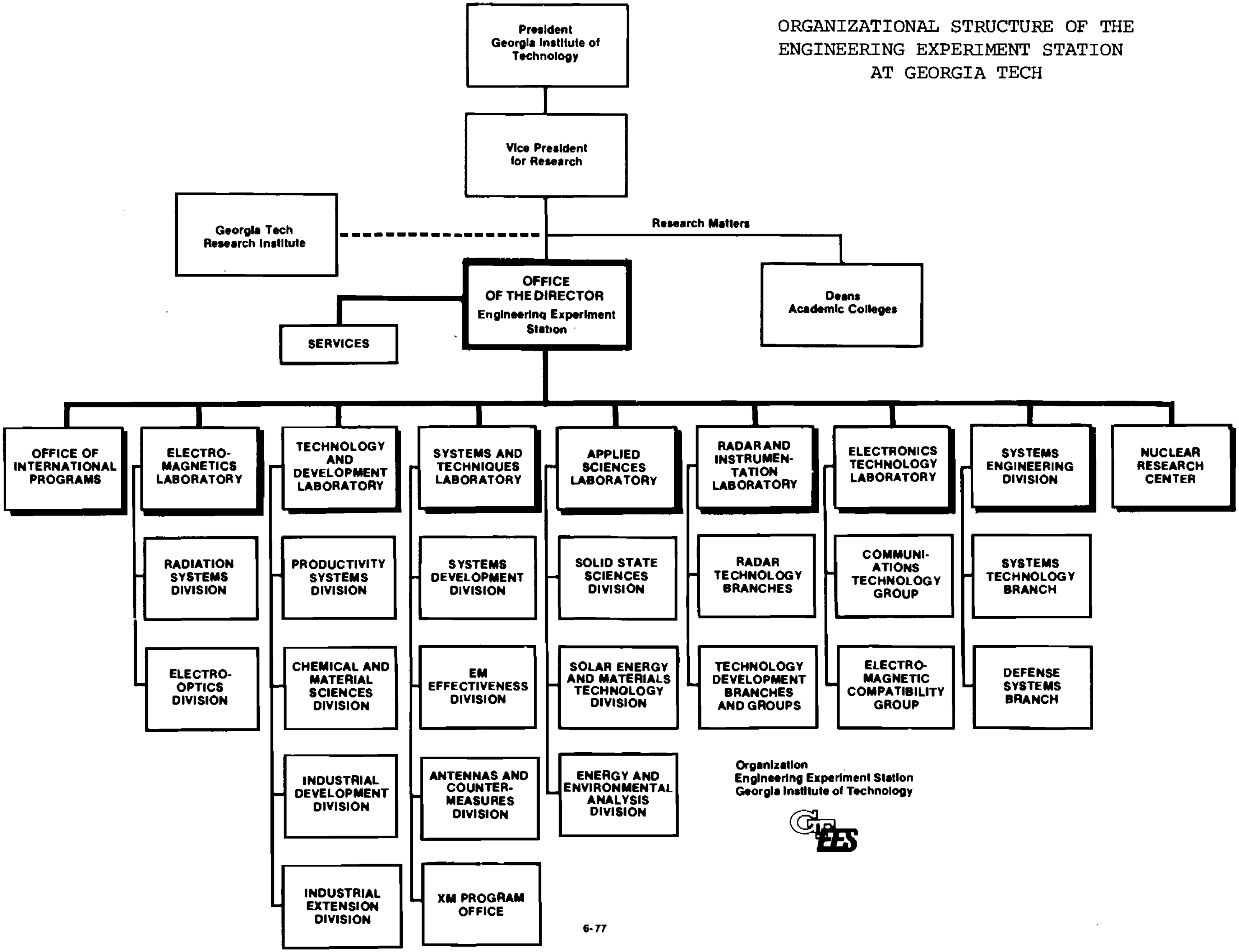
Recognizing the need in developing countries for a reliable supply of potable water and the corollary worldwide need for a long-lasting, low-cost, easily repaired, locally manufactured hand pump, the Agency for International Development (AID) began a series of contracts with the Battelle Memorial Institute to design and laboratory test a reciprocating shallow- and deep-well hand pump for LDC manufacture and use. A final design was developed and, in late 1976, AID contracted with the Office of International Programs at the Georgia Institute of Technology to evaluate the performance and acceptability of the AID pump in comparison with other pumps used in developing countries and the feasibility of local manufacture of the AID pumps. Cooperating with Georgia Tech on the project was the Central American Research Institute for Industry (ICAITI) and local Ministry of Health and AID officials in Costa Rica and Nicaragua.

The program has consisted of the manufacture of AID pumps in Nicaragua and Costa Rica, the purchase of locally available comparative pumps, installation of the pumps in rural villages, and evaluation of the field performance of each pump over a one-year period. One manufacturer in each country was selected to manufacture the AID pump. A minimum of 30 pumps of various kinds were installed in each country, and detailed, frequent monitoring of their operation was accomplished.

Organizationally, Georgia Tech had overall responsibility for the AID hand-operated water pump field testing. Members of the Engineering Experiment Station have been, and are currently, involved in national and international programs of community and area development, management and technical assistance to business and industrial firms, industrial and economic development training, market analyses, studies of new manufacturing opportunities, manpower resources and labor productivity, stimulation of small-scale industry, technology assessment, development and conservation of energy resources, housing resources, industrial economics, economic uses of industrial wastes, adaptive technology research and development, audiovisual presentations and multimedia documentation, and professional guidance in planning industrial and economic development programs. The organization of the Engineering Experiment Station is illustrated in Figure 1.

Figure 1

ORGANIZATIONAL STRUCTURE OF THE ENGINEERING EXPERIMENT STATION AT GEORGIA TECH



ICAITI, chosen as a Central American counterpart by Georgia Tech to enable efficient utilization of travel funds, to provide quick response to AID and to the Ministries of Health in Costa Rica and Nicaragua, and to take full advantage of its established working relationships with existing communities, industries, lending institutions, and governmental departments of Costa Rica and Nicaragua, is very similar to the Engineering Experiment Station. For more than 14 years, ICAITI has made significant contributions to the industrial development of Central America through the introduction of modern technologies and has completed a considerable number of related projects that have aided in the accomplishment of this program.

The program, more specifically, consisted of participation by Georgia Tech and ICAITI in the following activities:

1. Providing technical assistance for selected foundries and machine shops to locally manufacture the AID pumps.

2. Selecting and purchasing locally available pumps to be used in comparison with the AID pump.

3. Selecting 60 field-test sites for installation of 30 AID pumps and 30 locally available pumps (30 sites located in each of the two test countries).

4. Determining the quality of water through chemical and bacteriological analysis.

5. Preparing sites (preparing new wells or rehabilitating existing wells, as necessary).

6. Installing pumps.

7. Monitoring pump performance for a 12-month period.

8. Collecting and analyzing field data.

In gathering and analyzing data on the AID pump, seven areas have been of major concern:

1. Operational performance in the field.

2. Maintenance requirements and pump reliability.

3. Competitive cost and analysis of the economics of in-country manufacturing.

4. Manufacturing problems encountered.

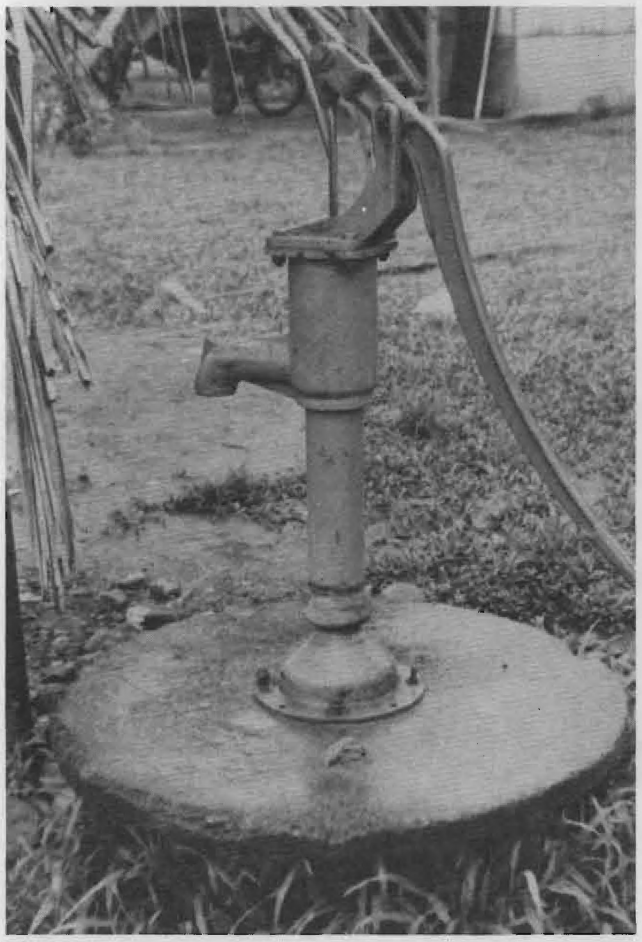
5. Needed design changes and future utilization.

6. Public acceptance and marketability.

7. AID pump design characteristics and specifications.

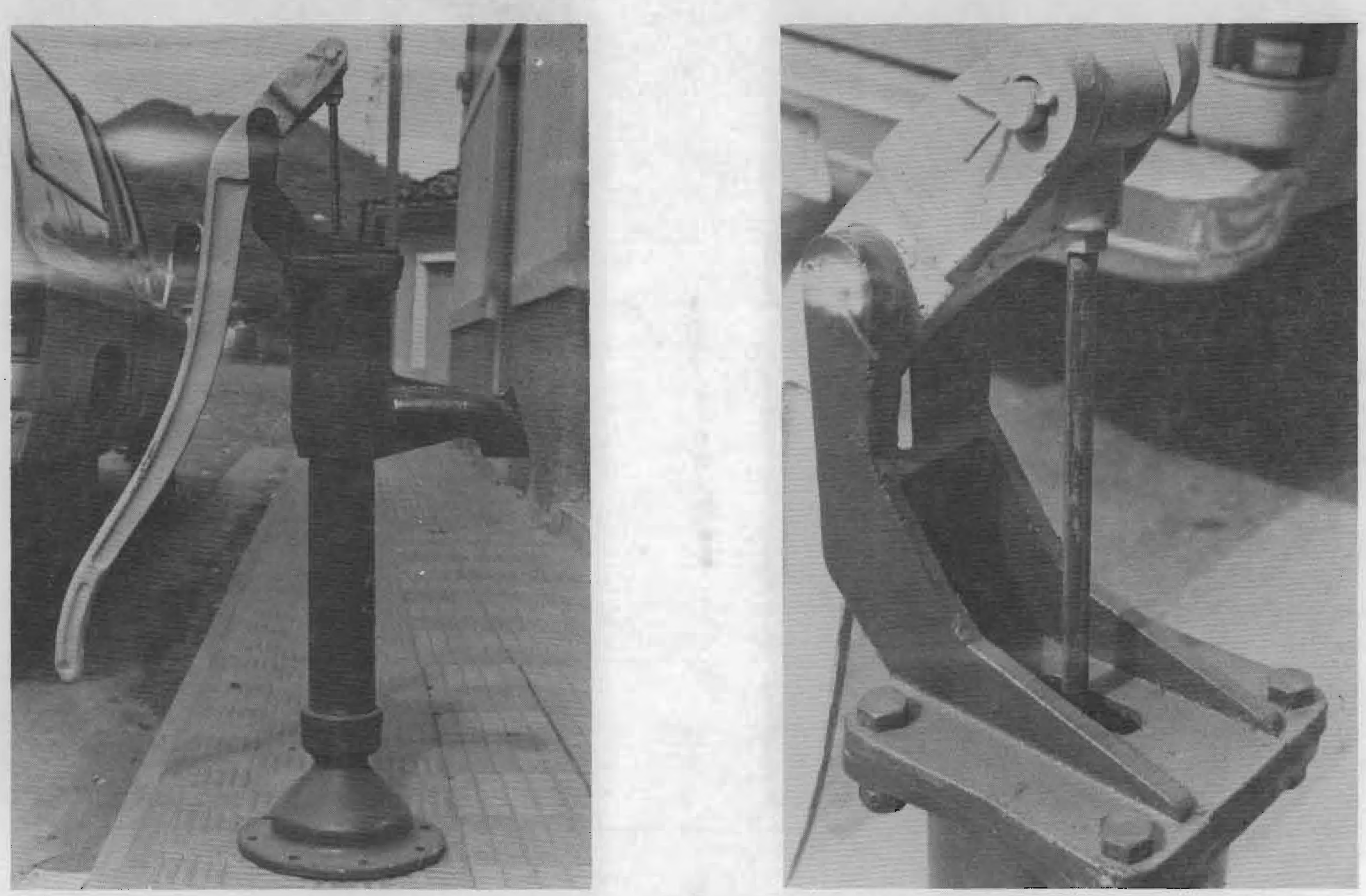
The program has shown that the AID hand pump is very adaptable to local manufacture in many developing countries and offers many benefits (spare parts availability, easy maintenance, low cost, durability, employment generation, increase of local income, and the diminution of foreign exchange outflow). The AID hand pump consists of a shallow-well version (the plunger, or piston, and its cylinder located above the water level) and a deep-well version (the plunger, or piston, and its cylinder located below the water level). Both versions are single-action, reciprocating, positive displacement type pumps. Photographs of these pumps, produced in both Costa Rica and in Nicaragua, follow.

COSTA RICA



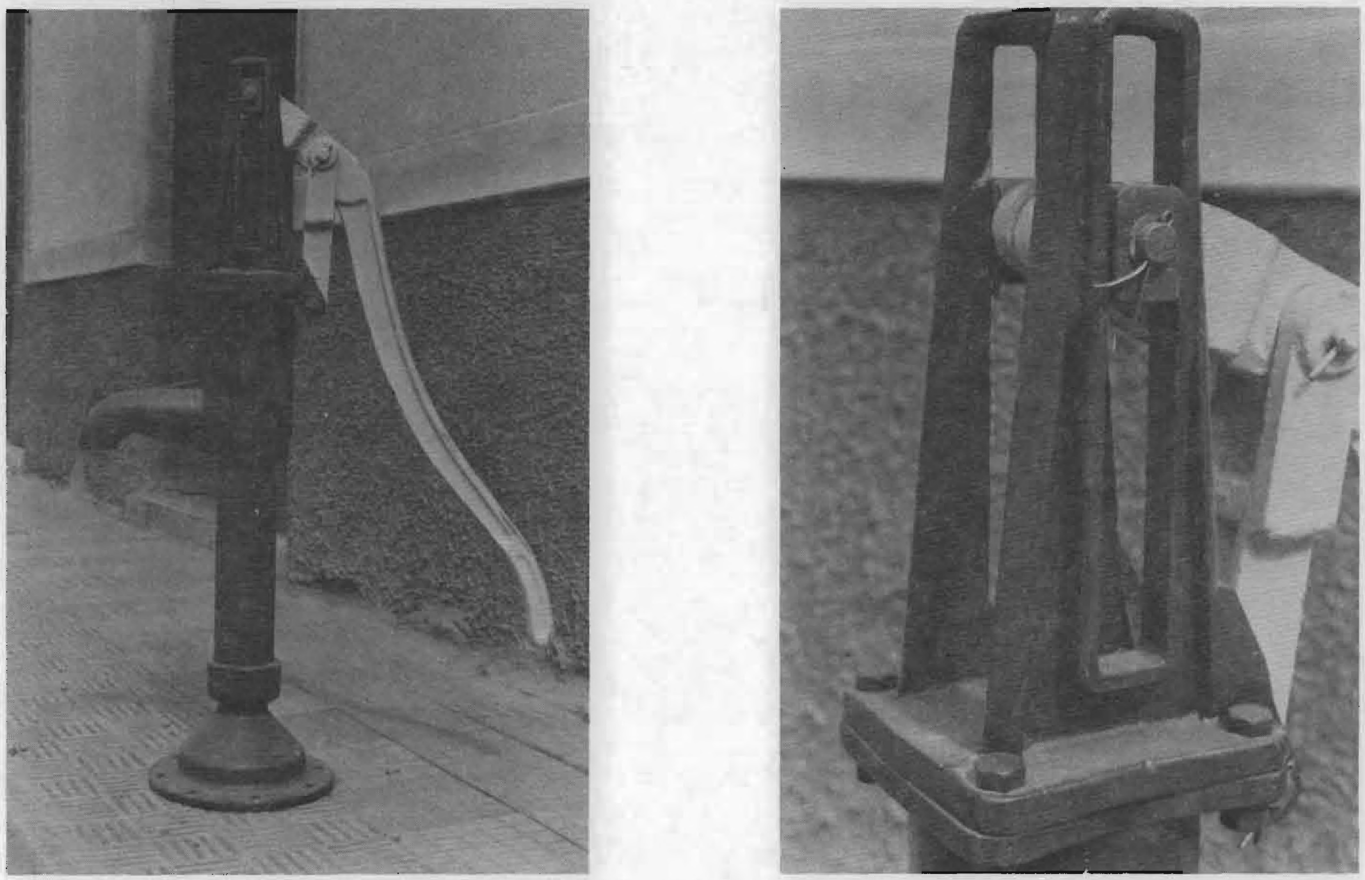
The AID shallow-well pump, left photo, and the AID deep-well pump, right photo, both manufactured in Costa Rica.

NICARAGUA



The AID shallow-well pump, manufactured in Nicaragua

NICARAGUA



The AID deep-well pump, manufactured in Nicaragua

COSTA RICA

Background

It is universally accepted that an adequate supply of water for drinking, personal hygiene, and other domestic purposes and an adequate means of waste disposal are essential to public health and well-being. Unfortunately, vast numbers of people in the developing world, most of them living in rural areas, do not have access to a safe and convenient source of water. When safe and convenient sources are available, satisfactory sewage disposal facilities normally are still unavailable.[1/]

Costa Rica was chosen as a test country because of a sizable well and hand-pump loan that had been made to that country by AID and because of the country's need for an expanded water-pump program. Provisions of the loan specifically included installation of water pumps on a large-scale basis, and it was felt that assistance in such areas as pump selection, installation techniques, and pump maintenance, as a part of this field-test program, would greatly benefit the government of Costa Rica. Costa Rican Ministry of Health and AID officials also strongly felt that a locally manufactured hand pump offered by the AID/Georgia Tech/ICAITI program had many advantages that should be included in the Costa Rican loan program (mainly employment generation, spare parts availability, and lower cost than for commercially available hand pumps).

One aspect of this project that was obvious from the beginning is that, even though Costa Rica is a developing country, it is much more developed than Nicaragua, and this shows up in the availability of rural community water supplies for the two countries. For instance, based on on-site surveys, representative test sites chosen for this project showed an average usage by approximately 60 persons in Costa Rica and 170 persons in Nicaragua. In Costa Rica, most communities of 250 inhabitants or more had some form of piped water system, while in Nicaragua, the size of the community usually exceeded 2,000 inhabitants before piped water was found. In Costa Rica, most communities had at least one well with a pump, if not piped water, and in Nicaragua, springs,

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[1/] Robert J. Saunders and Jeremy J. Warford, Village Water Supply (Baltimore, Maryland: The Johns-Hopkins University Press, 1976), p. 3.

rivers, and open, dug wells were the common sources of water. Costa Rica has a greater degree of electrification in rural areas, allowing the installation of motorized pumping systems that are not possible in many areas of Nicaragua. Further, the Ministry of Health in Costa Rica has had a limited hand-pump water program for some 15 years, while Nicaragua is just now in the beginning stages of such a program.

This does not mean that Costa Rica is without a need for improvement in its potable water delivery system. The Ministry of Health, for instance, has estimated that as many as 47,000 hand-operated water pumps are needed to provide a suitable water supply to the country's rural citizens. Further, many existing water pumps are inoperable because of a lack of maintenance and, where there are functioning pumps, most of the well structures are poorly designed and completely ineffective in sealing out contamination. There is also a great need for continued improvement in the proper governmental organization infrastructure to carry out an effective rural water supply program.

Active work began in Costa Rica in January 1977, when AID/Washington and Georgia Tech jointly agreed that Costa Rica and Nicaragua should be the test countries for the program described herein. A machine shop that purchases rough iron castings from a local foundry was contracted to manufacture 20 AID pumps (eleven deep-well and nine shallow-well). These pumps were produced and delivered to a Ministry of Health warehouse for storage and installation in April 1977. Two different kinds of pumps were chosen with which to compare the AID pump: a Dempster and a Japanese "Lucky" pump. Thirty-one sites, representative of Costa Rica, were chosen to receive the test pumps (16 AID pumps and 15 competitive pumps). (A pictorial monograph of all field-test sites in both Costa Rica and Nicaragua is contained in the Appendix of this report.)

Wells were randomly tested by chemical and bacteriological analyses prior to test-pump installation and found to contain large numbers of intestinal bacteria, indicating that contamination was not being sealed off from the water. The pumps were installed by the Ministry of Health, the wells were disinfected with a chlorine-yielding compound, and attempts were made to seal off the contamination sources. However, subsequent bacteriological testing has shown no improvement in the quality of the water, due to poor construction of the upper well structures by the rural villagers as well as their reluctance to accept an adequate amount of disinfection -- a matter that has caused great concern within the Ministry of Health. As a result, internal organizational changes have been made, and technicians and engineers are now being hired and trained in an attempt to alleviate the situation.

Field Test Sites

Table 1 shows those sites selected for the field testing in Costa Rica. They were chosen primarily because of their relative high usage (for Costa Rica) and accessibility. All sites were existing wells, all except one had been hand dug rather than drilled, and all were classified as either deep wells (as used herein, more than 25 feet in depth) or shallow wells (25 feet or less in depth). The usage at each site varied considerably, with an overall average of 60 people. Approximately half of these sites already had pumps, with the condition of the original pumps ranging from broken and inoperable to good. (The other half of the well sites had no previous pumps and, as a result, the new pumps replaced the bucket and rope system of retrieving water.)

Selection of the sites was made during the dry-season months of January, February, and March so that the water column figures would indicate annual low-water levels. However, the dry season of 1976-1977 took a disastrous toll on the sites, and, by the middle of May, many (approximately 50%) of the sites had dried up completely and had to be deepened before all pumps could be installed. In some cases, the wells had already been dug as deeply as possible, and substitute sites had to be found that were much more inaccessible and less desirable from a high-usage standpoint.

The general areas of site concentration were in the northwestern quadrant of Costa Rica in the vicinity of Nicoya, Santa Cruz, Liberia, and Las Cañas, and in the eastern area of Limon (see Map 1).

Manufacture of AID Pumps

Manufacturing Costs. A contract was signed with Mecanizados Mofama, S.A., located near San Jose, on January 28, 1977, for the manufacture of nine shallow-well type AID pumps and eleven deep-well type AID pumps. The prices of the pumps were as follows:

Table 1

SELECTED SITES FOR AID PUMP FIELD TESTS IN COSTA RICA

Site No.	Location	Well Situation	Well Type	Classification by Depth	Depth (m)	Average[1] Estimated Usage - No. People	Type of Original Pump	Condition of Original Pump	Has Water Meter	Type[2] of Pump Installed	Date Installed
1	La Palma de Abangares	Existing	Dug	Deep	11.55	70	Japanese	Broken		AID-DW	4/22/77
2	San Joaquin de Abangares	Existing	Dug	Deep	11.70	38	Dempster	Broken		AID-DW	4/22/77
3	IMAS, El Torito, Samara	Existing	Dug	Shallow	5.86	98	Dempster	Good	X	AID-SW	5/17/77
4	Hernandez de Santa Cruz	Existing	Dug	Shallow	4.30	51	Dempster	Good		Lucky	5/18/77
5	Curime de Nicoya (School)	Existing	Dug	Deep	10.35	125	Dempster	Poor		Dempster	5/19/77
6	Pijije de Bagaces (School)	Existing	Dug	Deep	10.80	38	Dempster[3]	Good		Dempster	5/19/77
7	La Javilla de Canas (School)	Existing	Dug	Shallow	6.10	91	Dempster	Poor		AID-SW	5/20/77
8	Zent #1, Matina (School)	Existing	Dug	Shallow	4.50	60	None	--	X	AID-SW	5/20/77
9	Corina, Matina	Existing	Dug	Shallow	7.60	17	Japanese	Poor		AID-SW	5/25/77
10	Bristol, Matina	Existing	Dug	Shallow	3.20	145	None	--	X	AID-SW	5/26/77
11	La Margarita, Bataan (School)	Existing	Dug	Shallow	3.85	41	None	--		Lucky	5/26/77
12	Corazon de Jesus	Existing	Dug	Deep	12.10	13	None	--		Dempster	6/1/77
13	Zent #2, Matina (Pedro Bustos)	Existing	Dug	Shallow	4.20	15	None	--		AID-SW	6/7/77
14	San Miguel de Venado	Existing	Dug	Deep	14.85	51	None	--		Dempster	6/15/77
15	Sabalito de Venado	Existing	Dug	Deep	19.10	24	None	--		Dempster	6/16/77
16	Pueblo Nuevo de Colorado (School)	Existing	Dug	Shallow	7.48	32	Dempster	Fair	X	AID-SW	6/22/77
17	San Francisco, Santa Cruz (School)	Existing	Dug	Shallow	6.30	30	Dempster	Fair		Lucky	6/23/77
18	Terciopelo de Nicoya	Existing	Dug	Deep	7.61	50	Dempster	Poor		AID-DW	6/24/77
19	Caimitalito de Nicoya (School)	Existing	Dug	Deep	10.50	34	Red Jacket	Broken		AID-DW	6/24/77
20	Judas de Chomes	Existing	Dug	Deep	9.85	118	Dempster	Broken	X	Dempster	8/12/77
21	Limonal de Abangares	Existing	Dug	Deep	9.30	30	Dominion	Broken		Dempster	9/2/77
22	Zent #3, Matina (Mariano Grijalba)	Existing	Dug	Shallow	4.90	8	None	--		Lucky	6/7/77
23	Santa Marta de Matina	Existing	Dug	Shallow	4.10	42	Dempster	Broken		Lucky	7/27/77
24	Tarcolesa de Orotina (School)	Existing	Dug	Shallow	4.30	32	Dempster	Fair		Lucky	8/4/77
25	Mesetas Abajo (School)	Existing	Dug	Shallow	6.30	15	None	--		Lucky	8/5/77
26	San Juan Grande	Existing	Dug	Deep	9.30	153	None	--		AID-DW	8/5/77
27	Sabana Grande	Existing	Dug	Deep	8.30	245	Dempster	Broken		AID-DW	8/10/77
28	Coyolito de Santa Cruz	Existing	Drilled	Deep	10.00	65	Dempster	Broken		AID-DW	8/11/77
29	La Lorena de Santa Cruz	Existing	Dug	Deep	9.60	28	None	--		Dempster	8/12/77
30	Lajas de Canas	Existing	Dug	Deep	10.00	19	None	--		AID-DW	8/29/77
31	Indiana Tres, Siquirres	Existing	Dug	Shallow	3.25	40	None	--		AID-SW	9/8/77

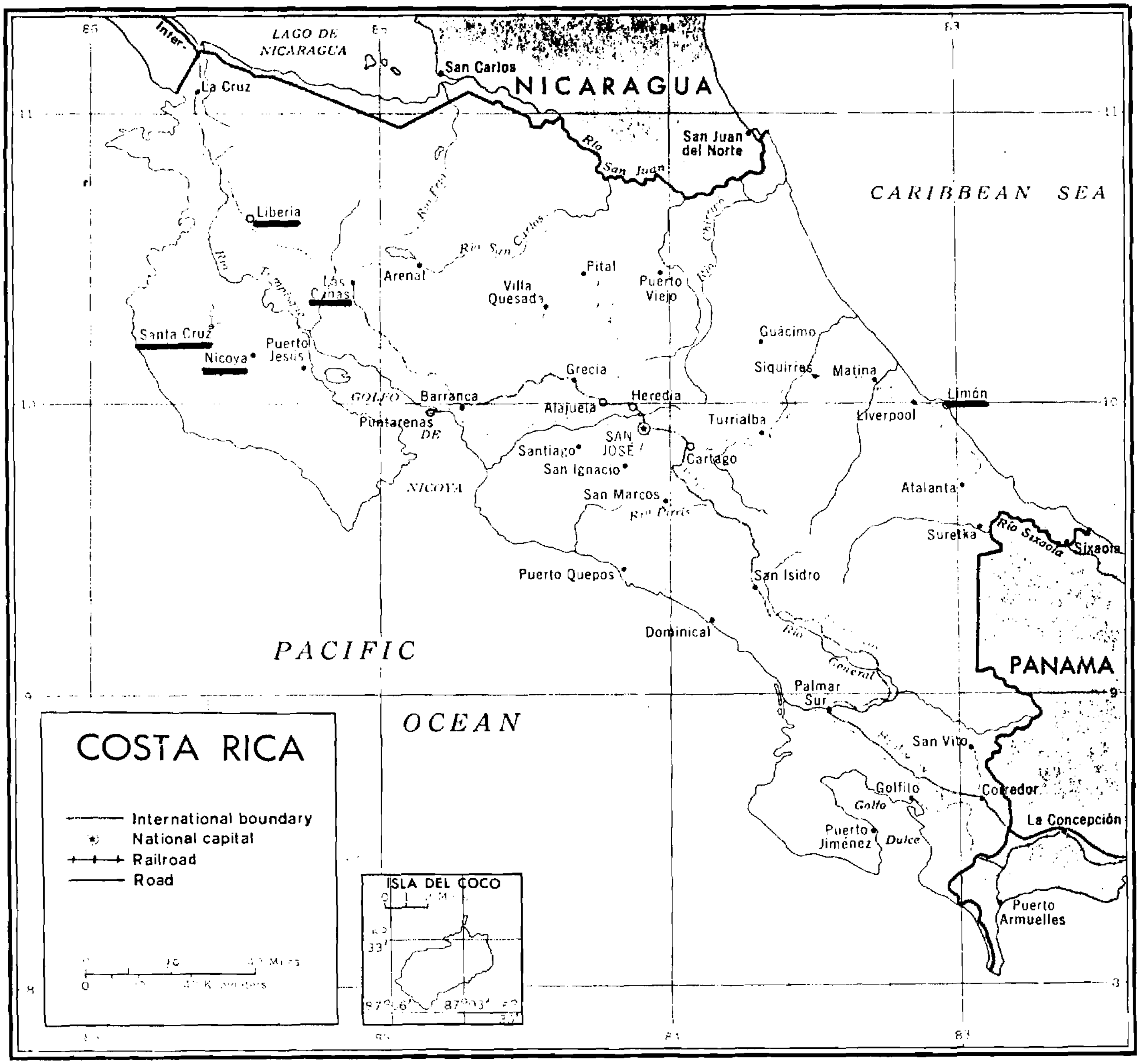
[1]Average estimated usage based upon individual user pattern surveys at each site.

[2]AID-DW: AID pump for deep well; AID-SW: AID pump for shallow well; Dempster: Dempster deep-well type pump; Lucky: Japanese-made shallow-well type pump.

[3]Pump being used for forced pumping to storage tank.

Map 1

COSTA RICAN TEST SITE AREAS



Sites in Costa Rica are concentrated in two major areas: (1) the northwestern quadrant around Nicoya, Santa Cruz, Liberia, and Las Canas, and (2) the eastern area of Limon.

Shallow-well	$ 98 (each)	
Deep-well	$128 (each)	
Patterns	$498 (one-time charge only)	

Because an order for 20 pumps does not offer any significant economies of scale, it is extremely costly to manufacture such a small order, especially if the manufacturer is not familiar with the many components of the pump and how they relate to each other. The manufacturer broke even on the 20 pumps actually produced and has recently updated his prices to reflect larger numbers of pumps per order and inflation:

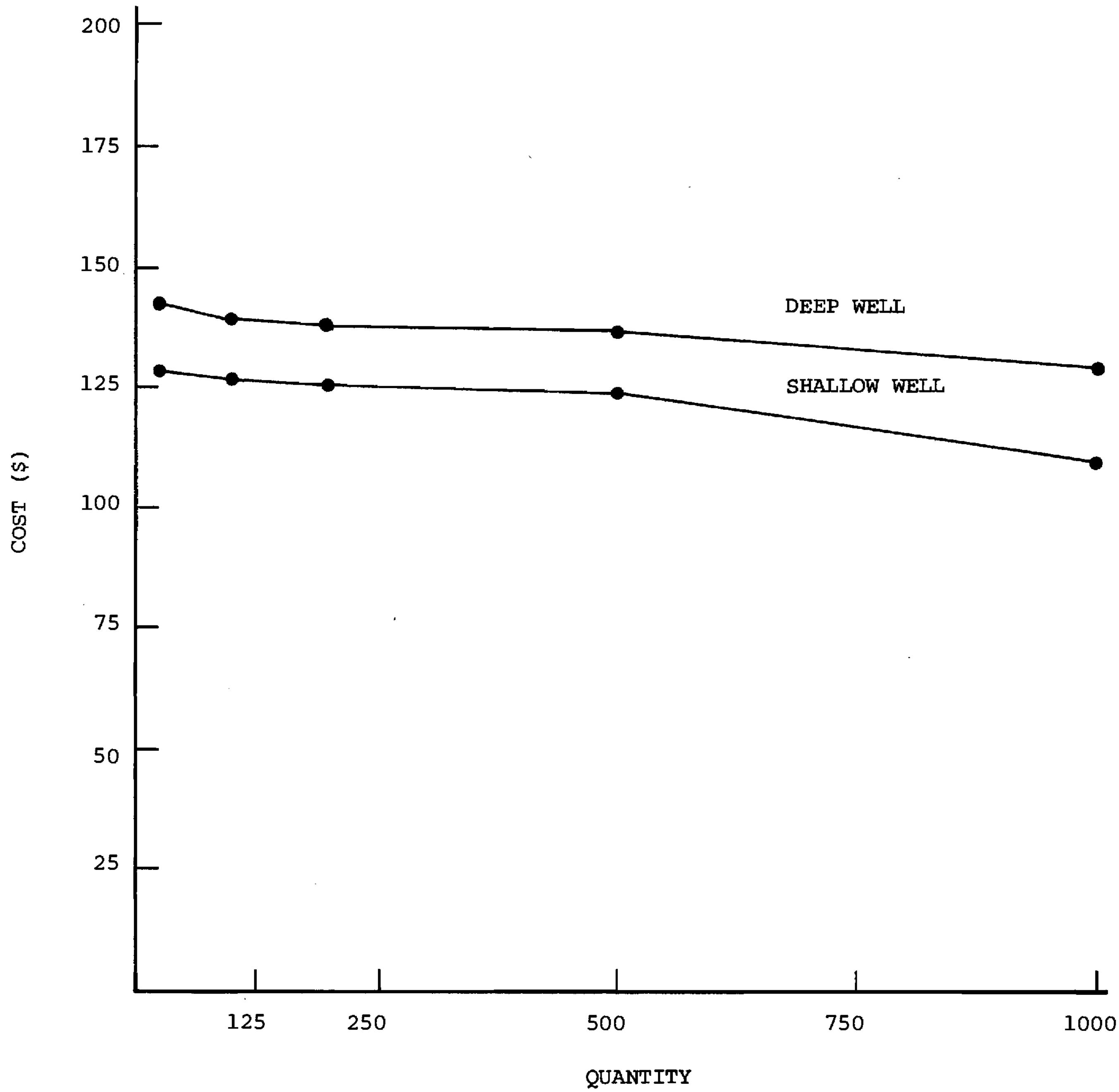
Quantity	Shallow-well ($ Price/Unit)	Deep-well ($ Price/Unit)
20	128.00	139.00
100	126.50	137.75
200	125.50	136.60
500	124.25	135.25
1,000	120.00	130.00

The above price scales are represented graphically in Figure 2. There are other foundries in Costa Rica that could be used for future orders to meet the 47,000 pump demand, mentioned earlier, and it is felt that the prices quoted by Mecanizados Mofama could be improved upon because of competitive pressures. The prices as quoted are competitive with imported pumps (Dempster, for example), and when other advantages of local pump manufacture are taken into consideration, such as spare parts availability, employment generation, local income increases and reduction of foreign exchange outflow, this possibility appears attractive to project personnel, AID officials in Costa Rica, and Ministry of Health personnel.

It should be noted that it has been very difficult during this program to arrive at a "representative" price for the AID pump because of extreme variances in manufacturing costs, especially overhead, between different countries and even between different manufacturers within the same country. For example, in Nicaragua, prior to placing an order with the manufacturer, price quotes were received from seven foundries that ranged from $69 (shallow-well) and $75 (deep-well) to $225 (shallow-well) and $250 (deep-well). During a trip to Ghana, the project director for this program discussed the AID pump with AID and Ghanaian government officials and discovered that prior investigations

Figure 2

COST BY QUANTITY TO PRODUCE
AID PUMPS IN COSTA RICA



into the use of the AID pump for that country indicated a cost of approximately $500 per pump (shallow-well or deep-well) for a relatively large order (100 pumps or more). Inquiries into the manufacture of the AID pump in the Dominican Republic have provided cost estimates ranging from $160 (shallow-well) and $200 (deep-well) to $261 (shallow-well) and $298 (deep-well), with the cost of patterns for making the castings included here in the price of the pumps, rather than as a separate cost.

To complicate matters even more, a judgment of expected quality must be balanced against the price of the pump and, in some cases, higher prices have not necessarily reflected a potential for the highest level of quality. However, various cost estimates show that the AID pump (shallow-well or deep-well) can be provided for an attractive price of below $100 (for instance, Indonesian foundries are manufacturing the deep-well pump for $60 and the shallow-well pump for $50 on orders of less than 50 pumps per order).

Manufacturing Specifications. The AID pumps were manufactured according to AID-approved Battelle drawings and with the following additional instructions:

1. The plunger rod was made from 1/2-inch diameter rod, rather than 7/16-inch, because of difficulty in locating a reliable supply of 7/16-inch stock. The pump rod nut, the rod end, and the plunger assembly also were changed to accommodate the 1/2-inch plunger rod.

2. The handle pivot pins were hardened to 40 R_C and steel bushings (60-64 R_C) were inserted in the pump handle holes. By taking this approach, the pins are expected to wear out before the handles, allowing easier repairs at the least cost.

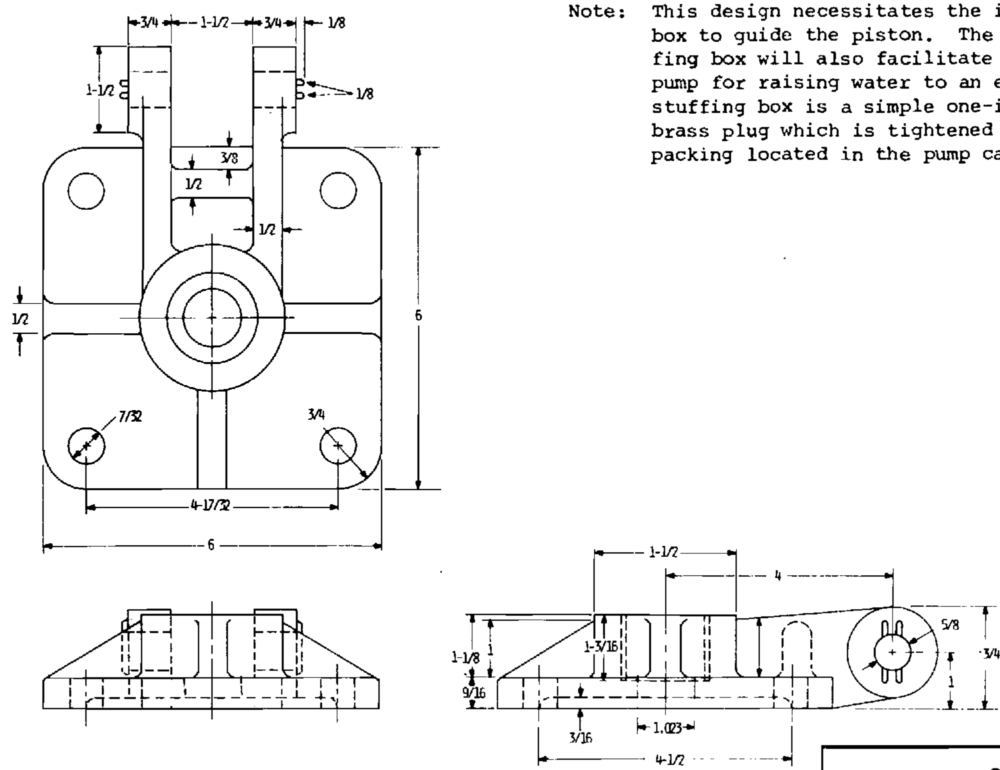
3. For the shallow-well pump, the 3-inch support pipe was internally coated with epoxy for a smoother surfaced cylinder finish. A bolted pump cap was chosen in preference to a pin-mounted pump cap (the bolted cap was felt to be sturdier and longer lasting).

4. For the deep-well pump, a bolted pump cap was chosen in preference to a pin-mounted option. The pump cap was modified, however, because of concern by the manufacturer that he could not cast this particularly complex part. (Figures 3 and 4 are working drawings of the locally modified cap and its accompanying handle fulcrum.) The pump cylinder was constructed from Schedule 40 PVC pipe.

Figure 3

MODIFIED DEEP-WELL PUMP CAP IN COSTA RICA

Note: This design necessitates the inclusion of a stuffing box to guide the piston. The addition of this stuffing box will also facilitate the use of the AID pump for raising water to an elevated tank. The stuffing box is a simple one-inch diameter threaded brass plug which is tightened against a fibrous packing located in the pump cap recess.

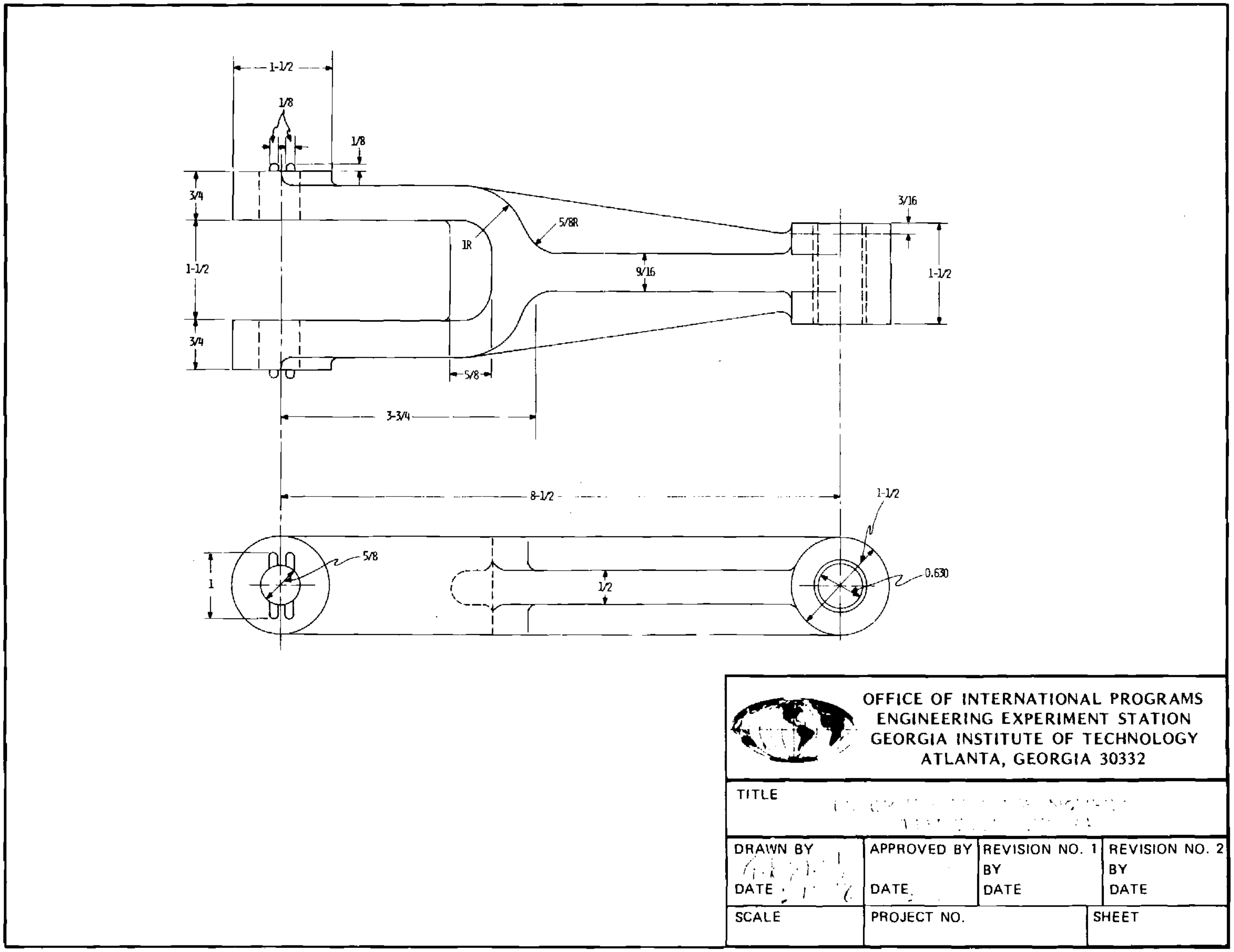


OFFICE OF INTERNATIONAL PROGRAMS
ENGINEERING EXPERIMENT STATION
GEORGIA INSTITUTE OF TECHNOLOGY
ATLANTA, GEORGIA 30332

TITLE			
DRAWN BY [illegible] DATE 7/15/78	APPROVED BY DATE.	REVISION NO. 1 BY DATE	REVISION NO. 2 BY DATE
SCALE	PROJECT NO.		SHEET

Figure 4

FULCRUM HANDLE FOR MODIFIED DEEP-WELL
PUMP CAP IN COSTA RICA



In addition to the above, all pumps were painted with an anticorrosive coating and consecutively numbered for identification purposes. In general, the manufacturing problems encountered were mostly associated with those to be expected from unfamiliarity with the pump itself on the first production order -- a prototype would have been very helpful -- and from poor castings. Visual inspection checks were carried out at periodic stages of production by Georgia Tech and ICAITI personnel, and, before acceptance of the finished pumps, all pumps were installed on a 55-gallon drum of water and checked for overall pump performance.

It should be noted that the foundry producing the castings had no laboratory facilities and used scrap metal as the source of raw materials. High-quality castings require a level of technology not generally expected to be found in developing countries and, without this technology, quality (such as degree of hardness) will vary from pump to pump and from one production order to the next. As a result, the pump castings produced in Costa Rica were rough in texture, contained voids and inclusions, and would be considered unacceptable by U.S. standards. However, subsequent castings produced for replacement parts showed significant improvement as the foundry gained experience in the production of these components.

Proper machine shop facilities and skilled machinists also are necessary for the manufacture of the AID pump. While the Costa Rican AID pump manufacturer had only a small shop (four employees) for the machining operations required, it was sufficient for small-quantity pump production. The machine shop contained a multiple-speed lathe, a vertical lathe, welding equipment, a drill press, a metal cutter, and assorted hand tools. Sandblasting equipment was not available but would have been useful in smoothing out the rough texture of the castings. Additionally, the machine shop did not have access to an oven, which was necessary for hardening the steel bushing inserts and the handle pivot pins (a competitor's oven was actually used).

Comparative Pumps

Two pumps were chosen for comparison with the AID pumps manufactured in Costa Rica -- a Dempster and a Japanese Kawamoto Daiichi "Lucky" pump. The Dempster model (see Figure 5) is considered by the authors of this report to be one of the better hand-operated water pumps in the world, has the cylinder

Figure 5

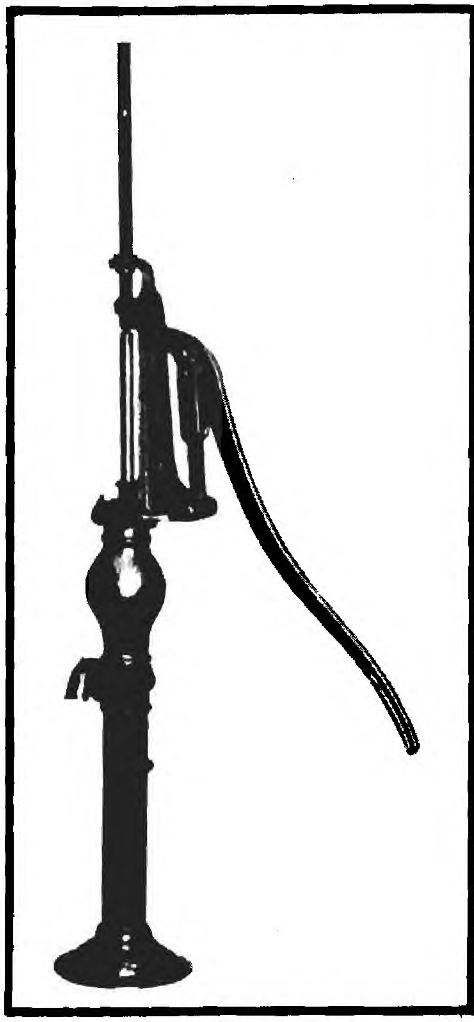
PUMPS and CYLINDERS

DEMPSTER®

CONSTRUCTION

DATA SHEET 380-3
ISSUE DATE 1976

CAST IRON



Dempster hand and windmill pumps are adapted for wells of any depth. Neat in design and substantially built, equipped with a 4-bolt adjustable flanged top, extra long handles and heavy steel bearer pins. Tops fitted with stuffing box and packing for tight seal on the piston rod. 4-position handle adjustment for up to 10 inch stroke. Large capacity air chamber for smooth force pumping. Furnished with syphon or compression spout. Syphon spout furnished unless otherwise ordered. 2 x 1-1/4-inch suction bushing furnished with each pump.

MODEL 36
Compression Spout
Furnished at slight Additional Cost.

MODEL 210F

MODEL 210F is a heavy-duty hand or windmill force pump. It has a 1-1/16-inch polished steel piston rod securely threaded to the flat bar. For wells of extreme depth, with large cylinders or continuous operation. This model is available with 2-1/2-inch tapping in the base at slight additional cost.

Type .... Hand & Windmill
Suction Tapped .... 2 in.
Piston Rod Threaded for,
Rod .... 7/16 in.
Pipe .... 3/8 in.
Tapping in Rear .... 1¼ in.
Approx. Weight .... 71 lbs.

MODEL 210F(CS) same as Model 210F except equipped with Model 36 Compression Spout.

MODEL 226F

MODEL 226F is normal duty hand or windmill force pump. It has a 11/16 inch steel piston rod fitted to the flat bar with a heavy cast set screw connection. For wells of shallow to moderate depth at normal farm and ranch operation.

Type .... Hand & Windmill
Suction Tapped .... 2 in.
Piston Rod Threaded for,
Rod .... 7/16 in.
Pipe .... 3/8 in.
Tapping in Rear .... 1¼ in.
Approx. Weight .... 70 lbs.

MODEL 226F(CS) same as Model 226 F except equipped with Model 36 Compression Spout.

DEMPSTER INDUSTRIES INC., Beatrice, Nebraska 68310 (402) 223-4026

below water level so that it can be used for wells of shallow or deep depth, and costs approximately $257 (1977 list prices) in Central America, delivered (the $257 includes the pump, the cylinder, and transportation). The "Lucky" pump (see Figure 6) is for shallow wells only (25 feet or less in depth), appears to be of good quality, has a porcelain-lined cylinder, and costs approximately $63 (1977 list prices) in Central America, delivered.

Monitoring System

Responsible individuals in each test community were provided with simple, printed report forms (see Form 1) designed to provide information covering community usage, pump physical condition, and functioning problems, if any. These forms were to be filled out and returned to Ministry of Health representatives every 15 days. If the returned forms showed complaints of any type concerning pump functioning or condition, a repair truck was dispatched to the site for investigation and repair of the defect. Should a serious pump failure occur that could not be corrected readily by Ministry personnel, the Ministry was instructed to request immediate assistance from Georgia Tech or ICAITI by telephone.

Copies of all report forms, as well as records of any repair work done on either AID or competitive pumps, were maintained at the Ministry of Health. This information was reviewed periodically by ICAITI for inclusion in pump performance control charts. In addition to the above, a periodic site-by-site inspection of all pumps was made by Georgia Tech and/or ICAITI personnel (approximately 10 times during the 12-month monitoring period).

Pump Performance

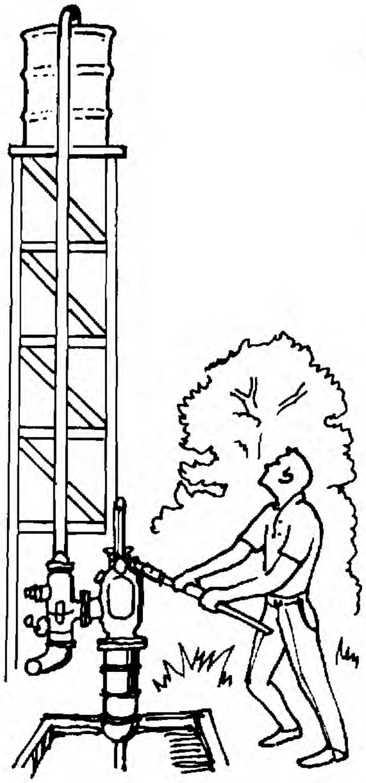
In general, the functional performance and acceptance of the Costa Rican-manufactured AID pump has been satisfactory, but serious casting defects were encountered which necessitated the replacement of five handles, two shallow-well caps, and one modified handle fulcrum. In all cases, these failures were caused by a lack of quality control at the foundry, which was not possible without laboratory facilities for testing the cast iron. The foundry used for the manufacture of the AID pumps in Costa Rica was representative of what might be found in many developing countries, but was not considered by project personnel to be the best in the country. Better foundries were available; however, these

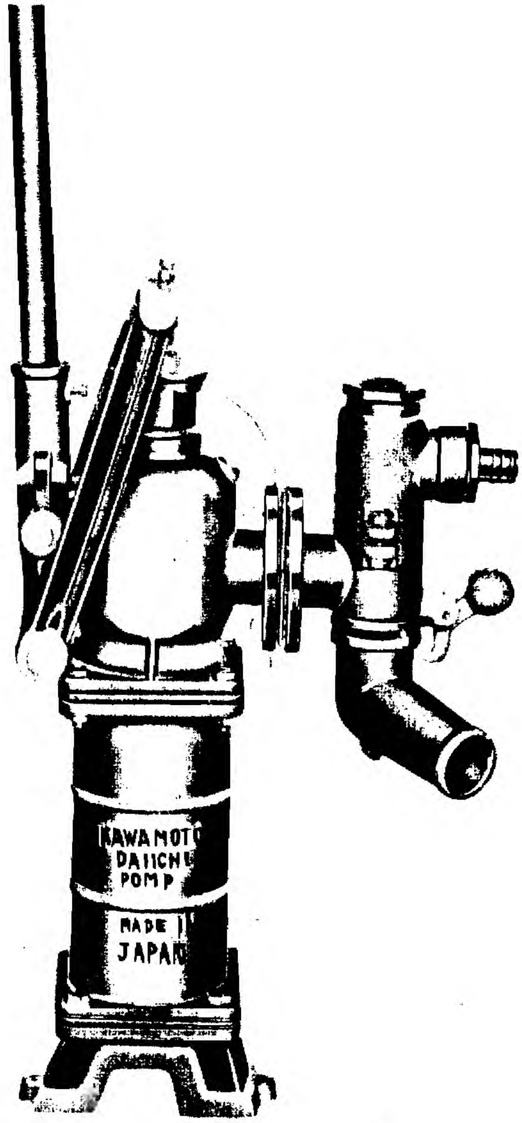
Figure 6

TRADE MARK

LUCKY PUMP

The most outstanding and unique feature of the "LUCKY" Hand Pump is the ConVertibility in its usage from an ordinary suctioning to pushing up water as illustrated.
No other brand of hand pump offers this double usage. Thus, it makes "LUCKY" a very economical buy, "TWO PUMPS FOR THE PRICE OF ONE"





\Special Features:

1. Chrome Pump Rod: A special hard chrome around the pump rod gives "LUCKY" added durability. Only gun-metal and steel used in main parts and casted with the best pig iron.
2. Porcelain Enameled Cylinder Liner: Unlike other pumps, "LUCKY" has a porcelain enameled cylinder liner which prevents rusting of the pump lining. Very little physical effort is required to get maximum amount of water in less time.
3. Leakage Impossible: A special double gland packing prevents water leakage which is very common in other kinds of pumps.
4. Vertical Pumping Motion: This kind of pumping motion makes it easy to connect the pump rod of the artesian wells, without any alteration.
5. Mud Free : The unique construction of"LUCKY"pumps eliminates mud which ordinary pumps cannot do.

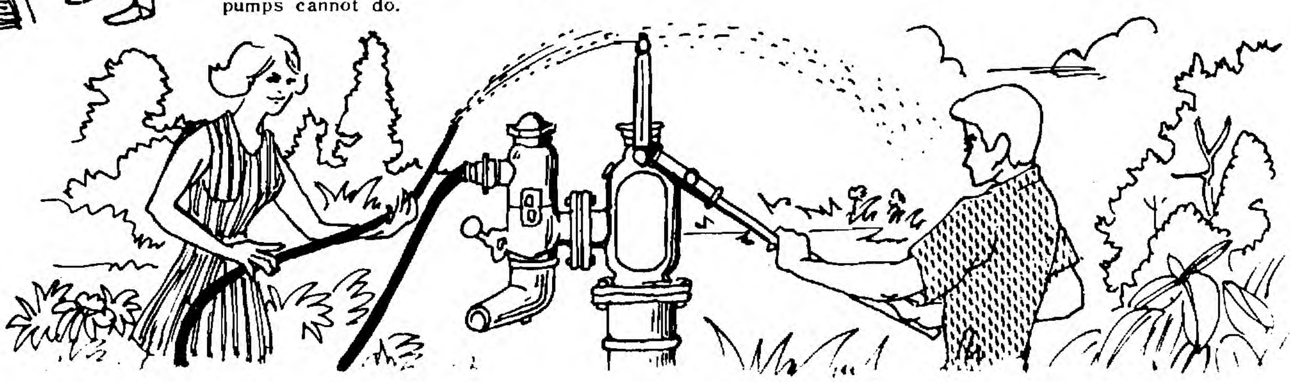
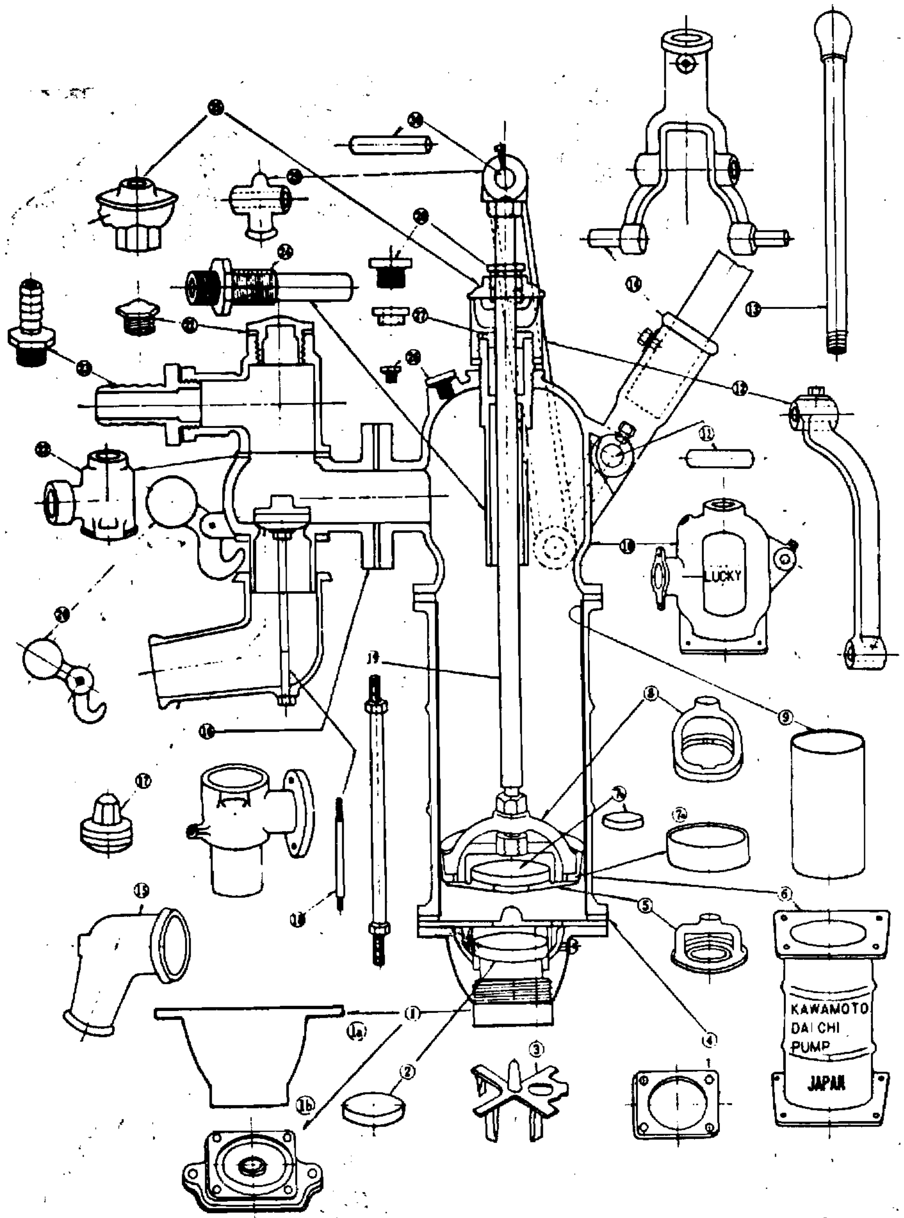


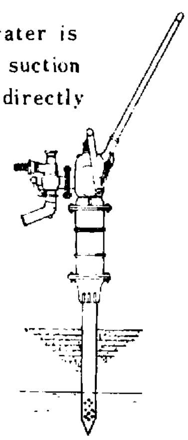
Figure 6(continued)



(1a) DRIVEN SUCTION VALVE BOX
(1b) DUG SUCTION VALVE BOX
(2) VALVE
(3) VALVE GUIDE
(4) RUBBER PACKING
(5) LOWER PISTON
(6) CYLINDER
(7) BOWL RUBBER
(7b) PISTON VALVE
(8) UPPER PISTON
(9) SLEEVE PORCELAIN ENAMELED
(10) CHAMBER
(11) HANDLE PIN
(12) DOUBLE ROD
(13) STEEL-PIPE HANDLE
(14) LEVER
(15) UNIVERSAL SPOUT
(16) FAUCET BOX
(17) FAUCET VALVE
(18) VALVE SPINDLE
(19) PISTON ROD
(20) STOP WATER WEIGHT
(21) FAUCET COVER
(22) UPPER FAUCET
(23) HOSE COUPLING
(24) INNER GLAND BOX
(25) GLAND BOX
(26) LEAKAGE SPOUT
(27) INNER GLAND
(28) GLAND
(29) ROD HEAD
(30) GUIDE PIN

DRIVEN-WELL

The underground water is sucked up through a suction pipe that is driven directly underground.



AVAILABILITY:
Good for every existing dug well and fit for driven wells.
USE:
General home use, sucking, pushing up to a height, fire-preventing and watering.
SPECIFICATION:
Vertical size, 85cm high, steel-pipe handle of 70cm long equipped.

Art. No.	Sort of Well pump	Inside Diameter of Suction Pipe	Suction Capacity Per Hour	More Than Suction Lift	More Than Pushing Lift	Weight
G-700	Driven	1 ¼"	1,100 imp. gallon	30 feet	50 feet	20 kg
G-701	Driven	1 ½"	1,100 imp. gallon	30 feet	50 feet	20 kg
G-702	Dug	1 ¼"	1,100 imp. gallon	30 feet	50 feet	20 kg
G-703	Dug	1 ½"	1,100 imp. gallon	30 feet	50 feet	20 kg

Form 1

Bimonthly Inspection Report of Water Pumps

Location: ____________________

Water pump number: ____________________

Date of inspection: ____________________

Name of inspector: ____________________

1. PHYSICAL CONDITION

Indicate the condition of the following water pump parts.

	GOOD CONDITION	WORN-OUT	BROKEN
Handle:	______	______	______
Plunger Rod:	______	______	______
Pins:	______	______	______
Nuts and Bolts:	______	______	______
Pump Stand:	______	______	______

2. PERFORMANCE

Indicate if there was a fault in the water pump in the last 2 weeks. Yes ___ No ___

If there was a fault, describe the problem and action, if any, taken to correct it.

____

____

Indicate if there have been complaints about the performance of the water pump. Yes ___ No ___

If there were, describe them.

____

Form 1 (continued)

3. USAGE

Indicate how many people use this well.

Less than 30	30 to 50	50 to 100	100 to 200	More than 200
____________	________	_________	__________	_____________

Indicate approximately how many times per day the pump is used.

Less than 30	30 to 50	50 to 100	100 to 200	More than 200
____________	________	_________	__________	_____________

4. GENERAL OBSERVATIONS

____

____

____

____

____

foundries were not interested in initial small orders even though the potential for much larger orders existed for the future.

Leather cups have shown excessive wear in AID shallow-well pumps which have been manufactured with metal cylinders and coated with epoxy. The cups appeared to wear out for two reasons: first, the walls of the cylinders, even when an epoxy coating is applied, are too rough and, second, the diameter of the metal base of the plunger follower where the leather cup sits was made too small (causing the leather cup to catch between the cylinder wall and the base, literally tearing the cup apart). The roughness of the cylinder lessens as the cup hones it down, but it still presents a problem. If numerous cup replacements during the life of the pump are not acceptable, then the cylinder must have a PVC sleeve or be mechanically honed down during its manufacture -- an operation that may not be available in some developing countries. The smallness of the diameter of the plunger's metal base was easily corrected by manufacturing units that are exact size or slightly on the plus side of specifications (in other words, closer quality control).

PVC cylinders for the AID deep-well pumps performed exceptionally well, and no leather cups were changed in this type of cylinder (which indicates that PVC or honed-down metal cylinders should be used for future pumps). There have been no significant problems with the U.S.-manufactured Dempster or the Japanese-manufactured "Lucky" pumps.

Table 2 shows the corrective maintenance performed on all pumps installed in Costa Rica. In addition, Ministry personnel conducted periodic preventive maintenance, such as lubrication of moving parts, minor adjustments and tightening of nuts and bolts.

As mentioned previously, pump usage in terms of the number of people expected to use each pump site was estimated by user pattern surveys. In order to verify the validity of these estimations, water meters were installed in five sites and total consumption readings were obtained over an eight-month period. These data when applied to the survey estimations showed a variation in per capita consumption from 0.3 gallons per day to 1.6 gallons per day from one site to another, and an overall average of 1.13 gallons per day.

Considering the fact that the great majority of the pumps in Costa Rica were installed at schoolhouses and that, therefore, students during school

Table 2

FIELD TEST PUMP MAINTENANCE - COSTA RICA

Site No.	Location	Corrective Maintenance During Test Period
		A. AID DEEP-WELL PUMP WITH PVC CYLINDER
1	La Palma de Abangares	Replaced handle (broken - casting defect)
2	San Joaquin de Abangares	NONE
19	Caimitalito de Nicoye	NONE
26	San Juan Grande	Replaced handle fulcrum (broken - casting defect)
27	Sabana Grande	NONE
28	Coyolito de Santa Cruz	NONE
30	Lajas de Canas	NONE
		B. DEMPSTER DEEP-WELL PUMP
5	Curime de Nicoya	NONE
6	Pijije de Bagaces	NONE
12	Corazon de Jesus	NONE
14	San Miguel de Venado	NONE
15	Sabalito de Venado	NONE
20	Judas de Chomes	NONE
21	Limonal de Abangares	NONE
29	La Lorena de Santa Cruz	NONE
		C. AID SHALLOW-WELL PUMP WITH STEEL CYLINDER
3	IMAS, El Torito, Samara	Replaced handle (broken - casting defect) 2 cup changes (excessive wear)
7	La Javilla de Cañas	Replaced handle (broken - casting defect) 6 cup changes (excessive wear)
8	Zent #1, Matina (school)	Replaced pump cap (broken - casting defect) Replaced handle (broken - casting defect) 1 cup change (excessive wear)
9	Corina, Matina	2 cup changes (excessive wear)
10	Bristol, Matina	3 cup changes (excessive wear)
13	Zent #2, Matina	1 cup change (excessive wear)
16	Pueblo Nuevo de Colorado	Replaced pump cap (broken - casting defect)
18	Terciopelo de Nicoya	1 cup change (excessive wear)

Table 2 (continued)

Site No.	Location	Corrective Maintenance During Test Period
31	Indiana Tres, Siquirres	Replaced handle (broken - casting defect) 2 cup changes (excessive wear)
		D. LUCKY SHALLOW-WELL PUMP
4	Hernandez de Santa Cruz	NONE
11	La Margarita, Bataan	NONE
17	San Francisco, Santa Cruz	NONE
22	Zent #3, Matina	NONE
23	Santa Marta de Matina	NONE
24	Tarcolesa de Orotina	NONE
25	Mesetas Abajo	NONE

Note: All AID pump components that broke during the test period were from the initial production order. No subsequently produced replacement parts failed during the test period (because of improved quality control by the manufacturer).

It is also interesting to note that the AID deep-well pump with PVC cylinder and leather cup required no cup replacement during the 12-month monitoring period in communities of as many as 245 users per day. Further, at the end of the test period, AID deep-well pumps were disassembled and inspected with no evidence of wear to the cylinder or to the leather cup itself.

hours were the principal consumers, the relatively low average per capita consumption shown above appears reasonable. The variation between sites may reflect errors in the survey estimates; therefore, in any future programs of this type, water meter readings would be the preferred method for determining usage.

All pump defects requiring corrective maintenance were due to known causes (poor castings, rough steel cylinders, etc). Maintenance problems, as could be expected, occurred randomly rather than at those sites with the highest usage. Therefore, no correlation could be shown between usage and corrective maintenance.

In order to further determine the durability of the different test pumps, attempts were made to correlate the different well depths with the amount of total stress exerted on the test pumps, assuming that the greater the depth of the well as well as the greater the distance to the water level, the greater the pump is stressed in pumping water over a given period of time.

Under normal operating conditions, a pump is never uniformly stressed, that is, the force per unit area varies throughout the structure of the pump. Due to the difficulty in calculating total stress for the entire pump, both theoretical and actual force (in Newtons) was determined on the delivery system of the pump. The theoretical force depended upon the volume of water being lifted from the well's water level plus the weight of the plunger rod and plunger assembly, while the actual force depended not only upon all the above, but also on friction and flow losses. Even though theoretical force and actual force are both directly proportional to stress, theoretical force generally increased with increasing well depth, while actual on-site force measurements randomly varied with depth (see Table 3).

Little correlation could be made between depth and <u>actual</u> force. These data indicate that friction plays a dramatic role in the amount of work required to pump water. If a water pump is kept in a well-lubricated state, has a smooth cylinder, has a cup that fits snugly but not too tightly inside the cylinder, and has no surfaces that grind against each other, the amount of actual force required to produce water will approach the theoretical force figure. If any of the above conditions are not met (which is almost always the case), the friction factor increases drastically and, as seen in Table 3, a pump operating from a depth of 3.8 meters (Site No. 11) can require three times as much work as a pump bringing up water from a well two times as deep (Site No. 9).

Table 3

FORCE EXERTED ON FIELD-TEST PUMPS (COSTA RICA)
AS A FUNCTION OF WELL DEPTH

Depth (m)	Site No.	Actual Force[1/] Newtons	Actual Force[1/] lb_f	Theoretical Force[2/] Newtons	Theoretical Force[2/] lb_f	AF/TF*	Type of Pump
3.2	10	117.9	26.5	52.5	11.8	2.2	AID-SW
3.3	31	80.1	18.0	52.9	11.9	1.5	AID-SW
3.8	11	350.1	78.7	50.7	11.4	6.9	Lucky
4.1	23	140.1	31.5	52.5	11.8	2.7	Lucky
4.2	13	420.4	94.5	53.4	12.0	7.9	AID-SW
4.3	4	280.2	63.0	54.3	12.2	5.2	Lucky
4.5	8	280.2	63.0	55.6	12.5	5.0	AID-SW
4.9	22	294.0	66.1	65.4	14.7	4.5	Lucky
6.1	7	264.7	59.7	74.7	16.8	3.5	AID-SW
6.3	17	419.5	94.3	69.8	15.7	6.0	Lucky
7.6	9	117.9	26.5	86.3	19.4	1.4	AID-SW
9.6	29	303.8	68.3	187.7	42.2	1.6	Dempster
10.0	28	382.4	86.0	190.7	42.9	2.0	AID-DW
10.0	30	235.3	52.9	190.7	42.9	1.2	AID-DW
10.8	6	303.8	68.3	199.7	44.9	1.5	Dempster

[1/] Calculations for Actual Force. Actual force figures were ascertained, on-site, by measurement with a heavy-duty spring scale of the force required to stroke the handle on each individually installed pump. This force was then multiplied by the length of the handle (from the fulcrum point to where the spring scale was attached) and divided by the distance between the plunger rod and the fulcrum point of the handle. The final result was the force required to lift water with no mechanical advantage. The equation used was the following:

$$F = \frac{(f)(d)}{D}$$

where

F = Actual force where no mechanical advantage is required to lift water from a well (Newtons).

*Note: Ratio of Actual Force to Theoretical Force.

f = Force exerted on the handle of the pump in order to lift water (Newtons)

d = Distance from the fulcrum point on the pump to where a person's force is exerted to stroke the handle (m)

D = Distance between the plunger rod and the fulcrum point of the handle (m).

For example, at Coyolito de Santa Cruz (Site No. 28) in Costa Rica, the variables are as follows:

$f = 47.8$ Newtons

$d = 0.8$ m

$D = 0.1$ m

Applying the above equation

$$F = \frac{47.8\ (0.8)}{0.1}$$

$F = 382.4$ Newtons

2/ Calculations for Theoretical Force. When calculations are made to determine the amount of theoretical force required on a hand pump in order to make it lift water, the total number of cubic meters of water in the drop pipe (from the pump base to the wells water level) and inside the pump must be determined. The equation used is the following:

$$V = \pi H\ [(R)^2 - (R^1)^2] + \pi h\ [(r)^2 - (r^1)^2]$$

where

V = Total volume (m^3)

H = Depth of the well from the pump base to the well's water level (m)

R = Radius of the drop pipe (m)

R^1= Radius of the plunger rod inside the drop pipe (m)

h = Height of the water inside the pump assembly (m)

r = Radius of the pipe inside the pump assembly (m)

r^1= Radius of the plunger rod inside the pump assembly (m)

When V is determined, it is converted into kilograms of water, assuming that one kilogram of water is equal to 1.00×10^{-3} cubic meters. The total number of kilograms of water is then added to the weight of the plunger rod and the plunger assembly. When multiplied by the gravity constant (9.807 m/sec^2), the total amount of force is the result. For example, at Coyolito de Santa Cruz (Site No. 28) in Costa Rica, variables are as follows:

$H = 9.0$ m

$R = 1.6 \times 10^{-2}$ m

$R^1 = 6.3 \times 10^{-3}$ m

$h = 5.5 \times 10^{-1}$ m

$r = 3.8 \times 10^{-2}$ m

Therefore,

$$V = \pi(9.0)\ [(1.6 \times 10^{-2})^2 - (6.3 \times 10^{-3})^2] + \pi(5.5 \times 10^{-1})\ [(3.8 \times 10^{-2})^2 - (6.3 \times 10^{-3})^2]$$

$$V = 6.1 \times 10^{-3} + 2.4 \times 10^{-3}$$

$$V = 8.5 \times 10^{-3}\ m^3$$

The total number of kilograms of water is:

$$\frac{1\ kg}{1.00 \times 10^{-3} m^3} = \frac{x\ kg}{8.5 \times 10^{-3} m^3}$$

$x = 8.5$ kg of H_2O

The total weight of the plunger rod and plunger assembly is 10.9 kg. The total force is thus:

$$F = (8.5\ kg + 10.9\ kg)\ (9.807\ m/sec^2)$$

$$F = 190.7\ kg - m/sec^2$$

$$F = 190.7\ \text{Newtons}$$

Water Quality -- Bacteriological and Chemical

Water samples were taken from 13 Costa Rican locations prior to installation of pumps to determine the level of bacteriological contamination in the water being used by rural villagers. (Three of the locations were subsequently dropped as test sites because of poor accessibility and infrequent use.) All but one location contained Escherichia coli in concentrations ranging from 3.6 to 1,100 per 100 milliliter (ml.) sample, as shown in Table 4.

Inasmuch as the presence of E. coli indicates probable fecal contamination, ideally none should be present. It was not surprising to find this existing condition, however, due to the poorly constructed wells. While the wells were disinfected at the time of their construction, imperfect sealing of the top, seepage of surface water and inadequate disinfection led to subsequent contamination. Bacterial quantity is subject to considerable variability, and frequent analysis of each site would have been required to provide definitive data; it is noteworthy, on the other hand, that there was only one location free of coliforms. (World Health Organization water quality standards for total coliforms and for E. coli consider 10/100 ml and 0/100 ml, respectively, as the highest permissible levels.)

Table 4

SUMMARY OF BACTERIOLOGICAL ANALYSIS, COSTA RICA
(BEFORE PUMP INSTALLATION)

Site No.	Location	Total Coliforms per 100 ml @ 35°C	E. coli per 100 ml @ 44°C
1	La Palma de Abangares	1,100	460.0
2	San Joaquin de Abangares	460	21.0
3	Conjunto IMAS, El Torito, Samara	290	290.0
5	Curime de Nicoya	43	3.6
6	Pijije de Bagaces	150	3.6
7	La Javilla de Canas	93	3.6
16	Pueblo Nuevo de Colorado	1,100	290.0
18	Terciopelo de Nicoya	0	0.0
19	Caimitalito de Nicoya	1,100	120.0
20	Judas de Chomes	210	150.0
--	San Buena Ventura de Colorado	460	240.0
--	Penas Blancas de Colorado	1,100	1,100.0
--	Nicoya (Barrio San Martin)	210	20.0

Note: All tests performed in accordance with Standard Methods for the Examination of Water and Waste Water, 13th Edition APHA, 1971.

Water disinfection has been a routine matter in Costa Rica during the installation of pumps, but there has been no laboratory analysis to reveal the extent of assumed contamination in the wells. Because many of the sites in Costa Rica had been disinfected in the past only to result in continued contamination, the sites were tested again after pump installation to measure the effectiveness of pump programs such as this one now being carried out in Costa Rica and Nicaragua.

The bacteriological analyses, shown in Table 5, indicate that all waters involved in the second sampling were polluted to some extent, and some were grossly polluted. The presence of E. coli was taken as an indication of fecal contamination, and thus, the possible presence of pathogens associated with the intestinal tract of humans or other mammals. Persistent failure to improve the qualities of these waters should, as a general rule, lead to condemnation of the water supply.

It should be stressed that existing, poorly constructed Costa Rican structures were used for this field test of the installation and operational performance of the AID hand pump, not improved structures such as was the case in Nicaragua, and, in addition, project personnel experienced a serious reluctance

Table 5

SUMMARY OF BACTERIOLOGICAL ANALYSIS, COSTA RICA
(AFTER PUMP INSTALLATION)

Site No.	Location	Total Coliforms per 100 ml @ 35°C	E. coli per 100 ml @ 44°C
1	La Palma de Abangares	23	3.6
2	San Joaquin de Abangares	39	3.6
4	Hernandez de Santa Cruz	1,100	150.0
5	Curime de Nicoya	more than 1,100	210.0
6	Pijije de Bagaces	1,100	23.0
7	La Javilla de Canas	more than 1,100	1,100.0
9	Corina	more than 1,100	93.0
10	Bristol	more than 1,100	210.0'
11	La Margarita	1,100	53.0
12	Corazon de Jesus de Kutru	1,100	35.0
13	Zent #2 (Sr. Pedro Bustos)	more than 1,100	1,100.0
14	San Miguel de Venado	1,100	460.0
15	Sabalito de Venado	1,100	1,100.0
16	Pueblo Nuevo de Abangares	1,100	43.0
18	Terciopelo de Nicoya	93	93.0
19	Caimitalito de Nicoya	more than 1,100	more than 1,100
--	San Fernando de Santa Cruz	1,100	28.0
--	La Pastora de Quepos	1,100	120.0
--	Santa Domingo de Quepos	290	35.0

Note: All tests performed in accordance with Standard Methods for the Examination of Water and Waste Water, 13th Edition APHA, 1971.

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on the part of rural villagers and Ministry of Health personnel to accept an adequate level of disinfection, all contributing factors to the poor improvement in the water quality of the wells. These factors have caused great concern to the Ministry of Health and, as pointed out earlier, the Ministry of Health is now making internal organizational changes to allow the hiring and training of qualified technicians and engineers in an attempt to correct the situation.

Because data were needed on chemical quality of the water represented by the field-test sites, further sampling of the water was carried out soon after pump installation (the results are shown in Table 6). This sampling was performed by the Ministry of Health and, with few exceptions, the characteristics of these waters were quite similar.

Future Potential for AID Pump in Costa Rica

As a result of the confidence and interest by AID/Costa Rica and Costa Rican Ministry of Health personnel in the AID pumps, it has been reported to Georgia Tech project personnel that 500 deep-well and 500 shallow-well type pumps will be purchased in the near future for installation in Costa Rica. The purchase of these 1000 pumps is out for bid to local manufacturers and delineates the importance of a cost effective, durable, locally manufactured hand pump where rural water supply programs are needed in developing countries.

Table 6

SUMMARY OF CHEMICAL ANALYSES OF WATERS -- COSTA RICA[a/]

Site No.	Location	Color	Total Solids	Dissolved Solids	Hardness $CO_3^=$	Hardness Non-$CO_3^=$	Hardness Total	Alkalinity	Fe	Mn	$SO_4^=$	$NO_3^=$	Observed pH	Saturation pH	Saturation Index[c/]
2	San Joaquin de Abangares	5	285.0	256.0	150.0	150.0	150.0	170.0	0.0	0.0	24.0	<1	6.6	11.5	-4.9
3	El Torito de Samara	5	196.0	163.0	112.5	0.0	112.5	120.0	0.0	0.0	38.4	<1	6.5	11.0	-4.5
4	Hernandez de Santa Cruz	5	234.0	231.0	170.0	0.0	170.0	172.5	0.5	0.0	24.0	<1	7.2	11.0	-3.8
5	Curime de Nicoya	5	267.0	223.0	100.0	47.5	147.5	100.0	0.10	0.0	19.2	<1	8.2	11.0	- .25
6	Pijije de Bagaces	5	262.0	231.0	105.0	0.0	105.0	152.5	0.0	0.0	24.0	<1	6.9	11.2	-4.2
7	La Javilla de Canas	5	352.0	316.0	190.0	0.0	190.0	230.0	0.0	0.0	29.0	1	6.7	11.0	-3.3
8	Zent #1	5	166.0	166.0	104.0	16.0	120.0	104.0	0.1	0.0	29.0	1	6.4	11.9	-5.5
9	Corina	5	210.0	172.0	160.0	7.0	167.0	160.0	0.1	0.0	25.0	<1	7.5	11.9	-4.4
10	Bristol	5	230.0	226.0	176.0	4.0	180.0	176.0	0.0	0.1	27.0	<1	6.6	11.9	-5.3
11	La Margarita	7	204.0	197.0	120.0	10.0	130.0	120.0	0.2	0.3	19.2	<1	6.5	11.9	-5.4
13	Zent #2	5	172.0	171.0	69.0	26.0	95.0	69.0	0.1	0.0	19.2	<1	6.4	11.9	-5.5
14	San Miguel de Venado	5	178.0	162.0	97.0	8.0	105.0	97.0	0.0	0.0	0.0	<1	6.7	11.9	-5.2
15	Sabalito de Venado	5	180.0	171.0	49.0	35.0	84.0	49.0	0.0	0.0	4.8	<1	6.5	11.9	-5.4
16	Pueblo Nuevo de Abangares	5	462.0	428.0	380.0	5.0	385.0	380.0	0.0	0.0	43.2	<1	7.1	11.7	-4.6
17	San Francisco de Santa Cruz	5	214.0	196.0	150.0	2.5	152.5	150.0	0.0	0.0	28.0	<1	6.9	11.6	-4.7
18	Terciopelo de Nicoya	5	412.0	411.0	350.0	5.0	355.0	350.0	0.0	0.0	29.0	<1	7.1	11.3	-4.2
19	Caimitalito de Nicoya	5	261.0	252.0	180.0	0.0	180.0	180.0	0.0	0.0	24.0	<1	7.0	11.2	-4.2
22	Zent #3	5	230.0	229.0	146.0	4.0	150.0	146.0	0.1	0.1	25.0	<1	6.6	11.8	-5.2
	WHO Limits:														
	Highest Desirable		500.0		100.0			--	0.10	0.05	200.0	(b)	7.0-8.5		
	Maximum		1,500.0		500.0			--	1.00	0.50	400.0	(b)	6.5-9.2		

a/ All Values mg/l except pH.
b/ Values above 45 mg/l considered potentially harmful, especially to children.
c/ Negative values indicate waters corrosive to metal.

NICARAGUA

Background

Data from 1975 show that 56% of the total population of Nicaragua has relatively easy access to piped water supplies; however, when this figure is broken down into urban and rural areas, it is seen that 100% of the urban population has easy access to this type of water system, while only 14% of the rural population has easy access. Comparative figures for Costa Rica are 72% (total), 100% (urban), and 56% (rural).[1/]

Nicaragua was chosen as a test country because of a rural water supply and hand-pump program loan by AID to that country involving the installation of hand-operated water pumps. The loan provisions included potable water systems that will construct 300-340 wells by the end of 1979. The AID/Georgia Tech/ ICAITI program has complemented this program by providing technical assistance in pump selection, installation techniques, and pump maintenance, and has enabled the Ministry of Health in Nicaragua to take advantage of locally manufactured hand pumps that can be produced at a cost lower than commercially available pumps. This local program increases spare parts availability, reduces foreign exchange outflow, and stimulates local employment, as well as provides all other benefits of the AID pump mentioned in the introduction to this report.

As in Costa Rica, program activities began in Nicaragua in January 1977. A local foundry was chosen to manufacture 20 AID pumps (eleven deep-well and nine shallow-well), which were produced and delivered to a Ministry of Health warehouse for storage and installation in May. Two kinds of locally available pumps were chosen for comparison with the AID pump: a Dempster and a Brazilian "Marumby" pump. A pump developed by the International Development Research Centre (IDRC) of Ottawa, Canada, also was used for comparison. Thirty sites, representative of Nicaragua, were approved to receive the test pumps (16 AID pumps and 14 comparative pumps), and all of the sites required extensive preparatory work before pumps could be installed. Pumps were installed by a Ministry of Health installation team, and the wells were disinfected with a

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[1/] World Health Statistics Report, Water and Sanitation, Volume 29, No. 10, published by the World Health Organization, Geneva, 1976.

chlorine-yielding substance. As in Costa Rica, the sites had chemical and bacteriological testing prior to installation of test pumps and showed excessive amounts of intestinal bacteria.

Field Test Sites

Table 7 shows the sites selected for field testing in Nicaragua. All of the wells were in existence at the beginning of the project, and one spring, Site No. 10 (El Naranjo), was adapted to support a pump. The sites consisted of 16 shallow wells and 14 deep wells equipped with 16 AID pumps and 14 comparative pumps. Usage was quite high for the sites, averaging 170 persons, and all wells required site improvement work of some kind (well deepening, application of a lining to the well, slab and drainage concrete work, and cleaning and disinfecting of the well). Seven originally selected sites posed problems that necessitated a search for substitute wells. The problems included the striking of hard rock during excavation, wells caving in, water sources polluted beyond the ability to correct quickly, and villagers deciding that they would prefer an electric pump and storage tank to a hand-operated water pump (even if the villagers had to pay for the electric pump and storage tank). The general areas of site concentration were in the northern section of Nicaragua in the vicinity of Condega, Esteli, and Matagalpa (see Maps 2 and 3).

It was the original intent of this project to use existing wells with pumps that were inoperable or in a state of disrepair and to merely replace the broken pumps with the test pumps. However, this approach was impractical in Nicaragua because there were few existing hand-pump installations; therefore, it was necessary to deepen 24 wells, provide linings for 12 wells, construct slabs for 30 well structures, and disinfect all 30 wells to complete installation of the pumps. The construction improvements were provided and supervised by PLANSAR, an impressive unit of the Ministry of Health.

Manufacture of AID Pumps

Manufacturing Costs. In manufacturing the AID pumps in Nicaragua, a somewhat surprising situation was encountered -- foundries were plentiful, but pattern makers, a very necessary requirement for local production, were almost nonexistent. A foundry was located that appeared to have the resources, including pattern makers, to manufacture a quality AID pump, and a contract was signed

Table 7

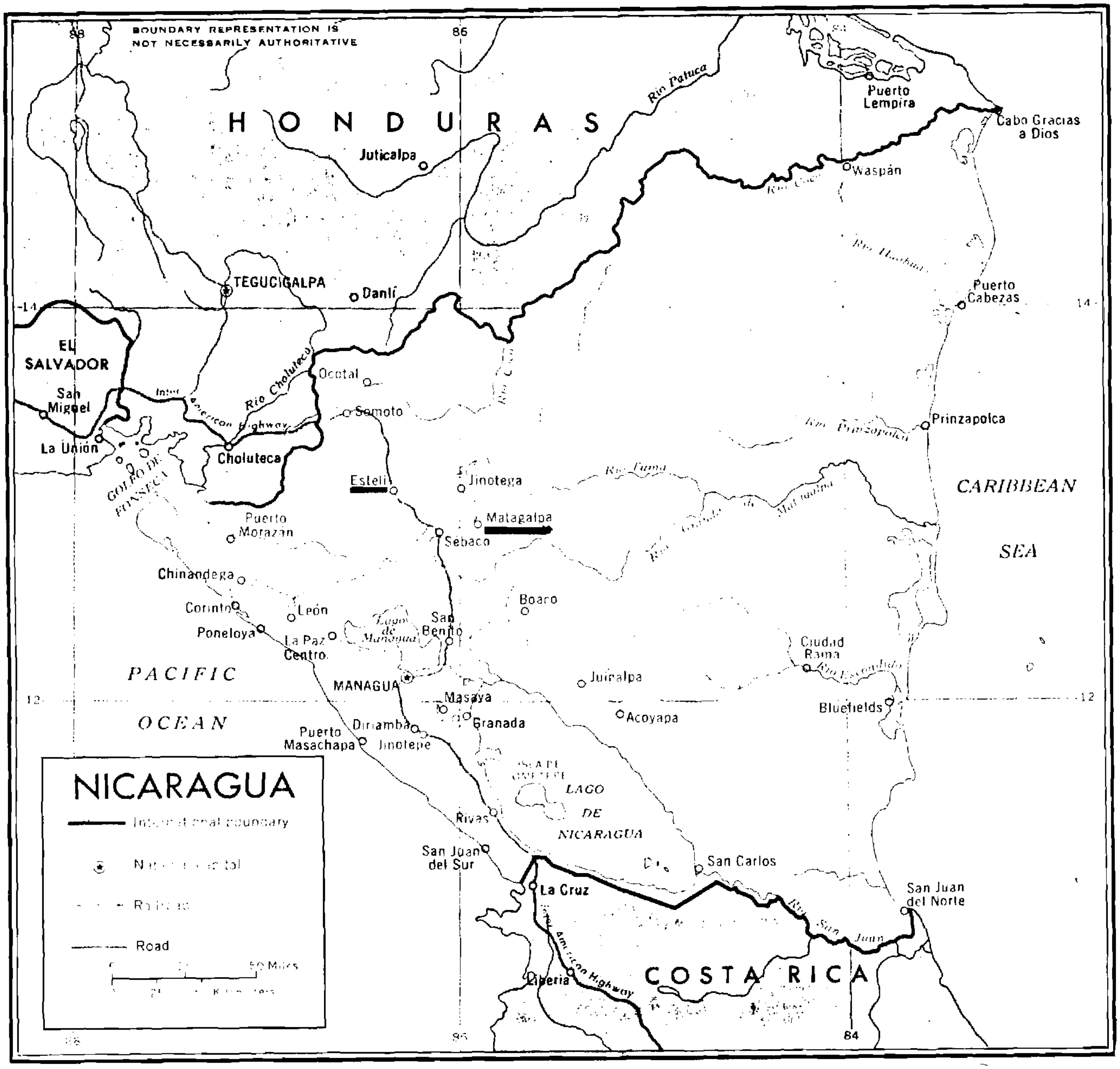
SELECTED SITES FOR AID PUMP FIELD TESTS IN NICARAGUA

Site No.	Location	Well Situation	Well Type	Classification by Depth	Depth (m)	Estimated Usage - No. People	Type of Original Pump	Condition of Original Pump	Has Water Meter	Type of Pump Installed	Date Installed
1	La Garita (Schoolhouse)	Existing	Dug	Deep	8.98	150	None	--		Dempster	4/27/77
2	Las Lajitas	Existing	Dug	Shallow	5.85	160	None	--	X	Marumby	5/12/77
3	La Lamilla	Existing	Dug	Deep	15.38	100	None	--		Dempster	5/12/77
4	San Antonio	Existing	Dug	Deep	10.42	100	None	--	X	Dempster	5/13/77
5	Las Mesas	Existing	Dug	Shallow	5.70	150	None	--		Marumby	5/16/77
6	Las Mangas	Existing	Dug	Deep	14.66	400	None	--		AID-DW	6/16/77
7	Llane Grande	Existing	Dug	Shallow	3.97	150	None	--		CAN-SW	5/28/77
8	San Diego	Existing	Dug	Shallow	5.03	100	None	--		Marumby	5/28/77
9	Mechapa	Existing	Dug	Deep	18.75	190	None	--		Dempster	6/4/77
10	El Naranjo	Existing	Spring	Shallow	3.12	210	None	--		AID-SW	5/28/77
11	Isidrillo	Existing	Dug	Deep	26.10	360	None	--		Dempster	6/11/77
12	La Concepcion	Existing	Dug	Shallow	2.85	280	None	--		AID-SW	6/8/77
13	El Rodeo	Existing	Dug	Deep	17.05	75	None	--		Dempster	6/17/77
14	Los Calpules (Stream)	Existing	Dug	Shallow	3.75	150	None	--		AID-SW	6/22/77
15	Los Calpules (Schoolhouse)	Existing	Dug	Deep	9.45	150	None	--		Dempster	6/22/77
16	Paso Hondo	Existing	Dug	Shallow	7.55	75	None	--		Dempster	6/23/77
17	Quebrada Arriba	Existing	Dug	Shallow	4.73	150	None	--		Marumby	7/21/77
18	Las Lajas	Existing	Dug	Shallow	6.65	90	None	--		AID-SW	7/26/77
19	Los Hatillos (Plaza)	Existing	Dug	Deep	17.19	100	None	--		AID-DW	7/26/77
20	Los Hatillos	Existing	Dug	Deep	17.25	100	None	--		AID-DW	7/27/77
21	Musuli	Existing	Dug	Deep	10.16	50	Dempster	Broken		AID-DW	7/27/77
22	Los Rincones	Existing	Dug	Deep	9.46	150	Dempster	Broken		AID-DW	7/28/77
23	Santa Rosa	Existing	Dug	Deep	17.60	656	Dempster	Broken	X	AID-DW	7/29/77
24	El Jocote	Existing	Dug	Deep	15.00	150	None	--		AID-DW	7/28/77
25	Mechapa - La Conception	Existing	Dug	Shallow	2.95	54	None	--		AID-SW	7/29/77
26	Licoroy	Existing	Dug	Shallow	5.00	50	None	--		AID-SW	7/30/77
27	Tomabu	Existing	Dug	Shallow	2.50	250	None	--		AID-SW	7/29/77
28	El Espinal #1	Existing	Dug	Shallow	3.50	360	None	--	X	AID-SW	7/30/77
29	El Espinal #2	Existing	Dug	Shallow	5.95	300	None	--	X	AID-SW	7/30/77
30	Sabana Grande	Existing	Dug	Shallow	2.80	75	None	--		Marumby	8/9/77

Note: AID-DW: AID pump for deep well; AID-SW: AID pump for shallow well; Dempster: Dempster deep-well type pump; Marumby: Brazilian shallow-well type; CAN-SW: Canadian pump for shallow well.

Map 2

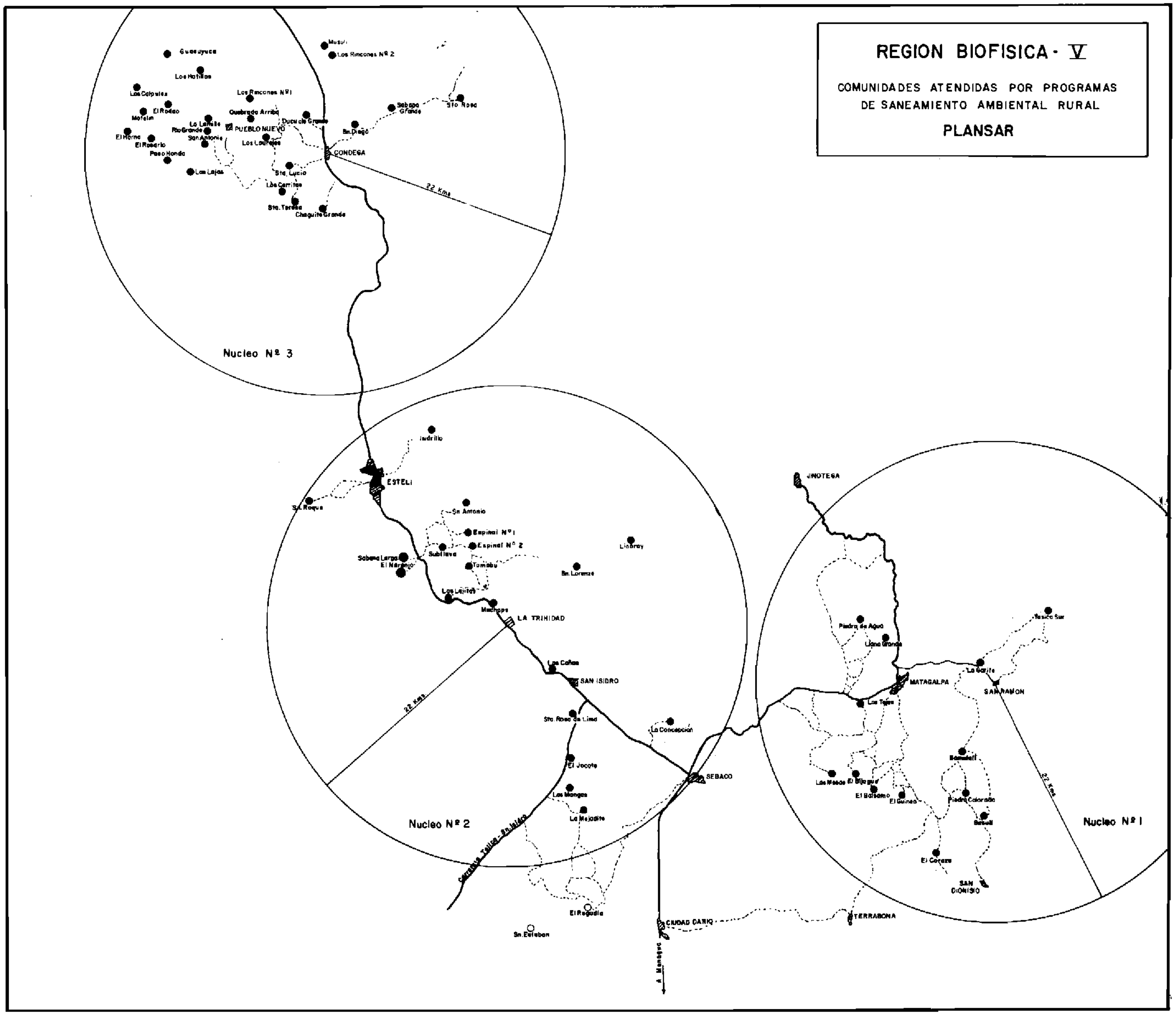
NICARAGUAN TEST SITE AREAS



Sites in Nicaragua are concentrated in the northern part of the country, near Condega (not shown on this map), Esteli, and Matagalpa.

Map 3

NICARAGUAN TEST SITE AREAS



on January 22, 1977, between Georgia Tech and Complejo Metalurgico Especializado, S.A. (Cometales) for the manufacture of eleven deep-well pumps and nine shallow-well pumps. The prices of the pumps, for an order of 20, were as follows:

Shallow-well	$ 69	(each)
Deep-well	$ 75	(each)
Patterns	$1,000	(one-time charge only)

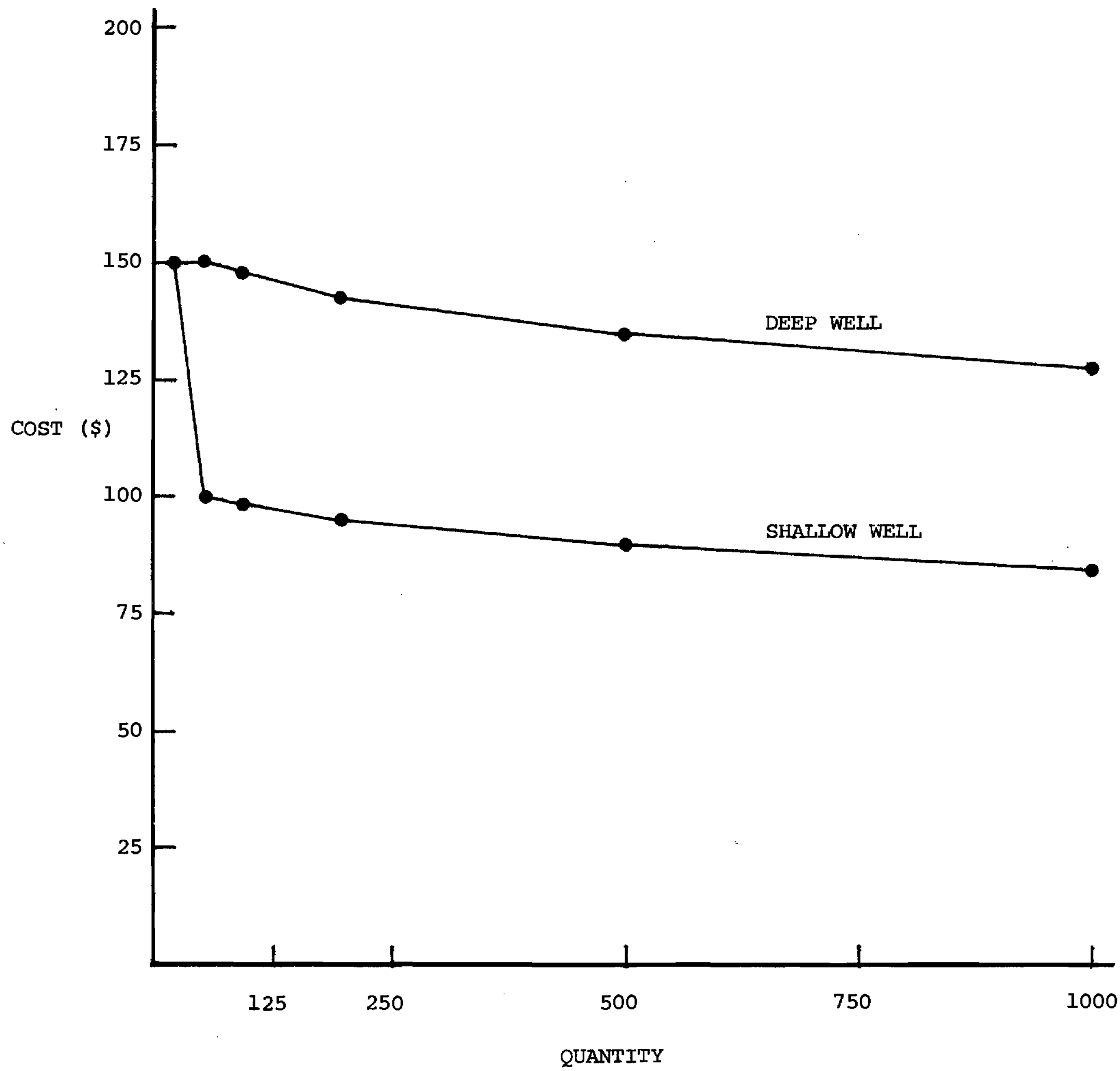
Based on the manufacturer's experiences with the first production run of the pumps, the following prices have been formally quoted for future orders, and are presented graphically in Figure 7.

Quantity	Shallow-Well ($ Price/Unit)	Deep-Well ($ Price/Unit)
20	150	150
50	100	150
100	98	147
200	95	142
500	90	135
1000	85	127

As was the case in Costa Rica, an order for only 20 pumps offered no significant economies of scale, and start-up costs were higher than originally expected because the manufacturer was totally unfamiliar with the working components of water pumps. The manufacturer encountered many unforeseen problems that increased his costs, such as the inability to cast the deep-well pump cap as specified and to obtain correctly sized PVC (3-inch inside diameter) for the deep-well cylinder, as well as a severe drought that struck Nicaragua which restricted the supply of hydroelectric power to the point that the manufacturer was allowed only four hours per day of electricity to run his plant. As a result of the manufacturer's experiences with the first production run of the AID pump, much higher price quotes have been submitted to the Ministry of Health for future orders. It is felt that the increased prices are over-inflated and, considering the weight of the AID pump (approximately 75 lbs.) versus a general foundry pricing guideline for Central America of between one and two dollars per pound (depending on complexity of the product), a more realistic pricing structure would allow the AID pump (both shallow-well and deep-well) to be manufactured and sold for less than $100 with reasonable profit to the manufacturer.

Figure 7

COST BY QUANTITY TO PRODUCE
AID PUMPS IN NICARAGUA



Manufacturing Specifications. AID pumps in Nicaragua also were manufactured according to AID-approved Battelle drawings with the following modifications:

1. The plunger rod was made from 1/2-inch diameter rod, rather than 7/16-inch stock. The pump rod nut, the rod end, and the plunger assembly also were changed to accommodate the 1/2-inch plunger rod.

2. The handle pivot pins were hardened to 40 R_C, and steel bushings (60-64 R_C) were inserted in the pump handle holes.

3. For the shallow-well pump, the 3-inch support pipe was internally coated with epoxy for a smoother-surfaced cylinder finish. A bolted pump cap was chosen in preference to a pin-mounted pump cap.

4. For the deep-well pump, a bolted pump cap also was chosen in preference to a pin-mounted pump cap.

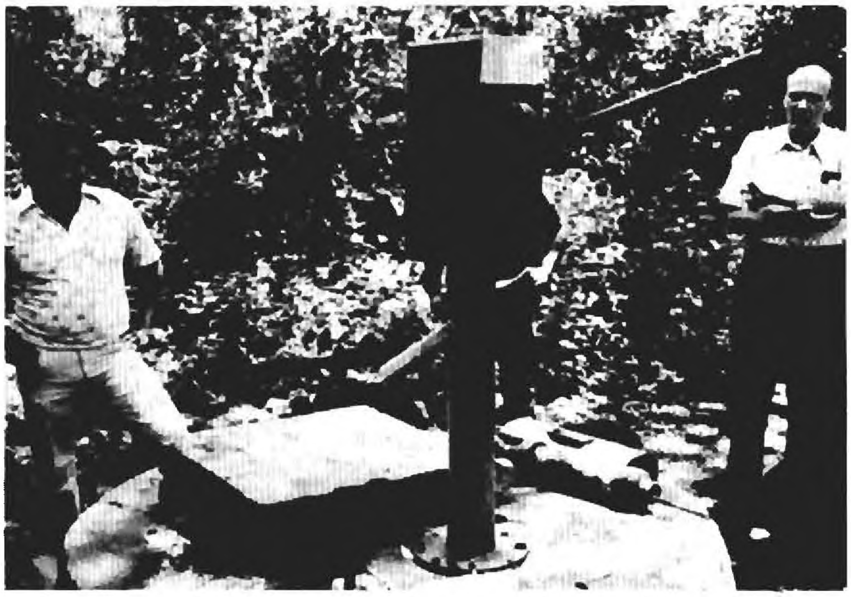
The AID pump manufacturer in Nicaragua had a complete, integrated foundry and machine shop with trained metallurgists in the day-to-day management of the facilities for the casting process, a quality control ingredient that is not normally expected to be found in developing countries. While it appears that the AID pump is adaptable to local manufacture in Nicaragua, the requirement of available casting facilities will restrict the use of the pump in some developing countries.

Comparative Pumps

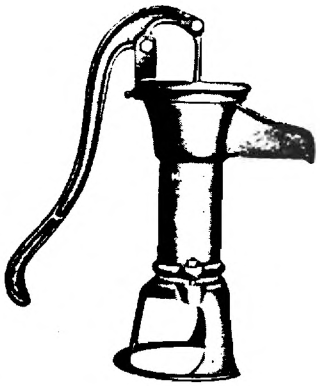
Two pumps that were locally available to the people of Nicaragua were chosen for comparison with the AID pump. These pumps were the Dempster (for shallow or deep wells) and a Brazilian "Marumby" pump (for shallow wells only). A pump developed by IDRC (for shallow or deep wells) also was used for comparison purposes (see Figure 8). The Dempster is designed for heavy-duty use in both shallow and deep wells, has either a brass-lined or PVC cylinder, is made of cast iron, and has a very good worldwide reputation, as pointed out earlier. The Brazilian pump (see Figure 9) uses a 1 1/4-inch drop pipe (as do the Dempster and AID pumps) and has a cylinder of smooth cast iron with an internal diameter of slightly over three inches (3.1"). The pump developed by IDRC uses a 3-inch diameter PVC drop pipe that is unique in that it also serves as the cylinder for the piston assembly (which can be inserted into or withdrawn from the cylinder while the cylinder and drop pipe are attached to the pump that is secured to the well's upper structure).

Figure 8

THE IDRC PUMP



The above photo is of the IDRC-developed pump that was installed at Llano Grande (Site No.7), in Nicaragua. The pump is made of indigenous materials (wood, galvanized iron pipe, and PVC pipe) and represents a design that simplifies hand pumps mechanically by substituting plastic pipe for traditional steel and cast iron. The casing is three-inch PVC pipe that serves as the drop pipe and the cylinder housing the piston assembly (this allows the piston and check valve to be brought up for inspection by pulling up the plunger rod without disassembling the drop pipe). Both piston and check valve are made of the same interchangeable components: perforated plastic discs with flapper valves covering the holes. The pump handle is made of standard galvanized iron pipe and the pivot points use oil-impregnated wooden bearings.



BOMBA SIMPLES

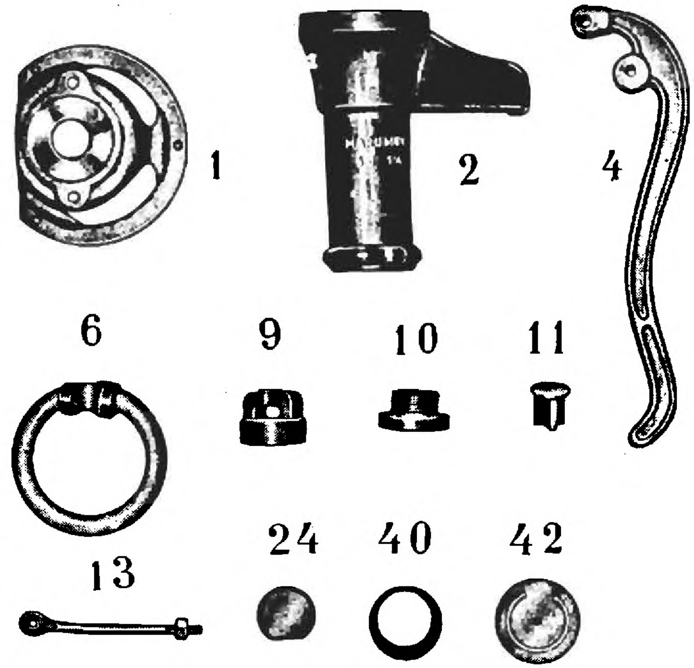
(BICA DE JARRO)

Tipo BJ

Para cano de 1¼" com pistão de ferro Cr$..

ESPECIFICAÇÕES:

Sucção cano de (Suction tube)	1¼"	
Altura do corpo (Height of body)	280	mm.
Diâmetro interno do cilindro (ID of cylinder)	80	mm.
Rendimentos em 55 movimentos do pistão por minuto (Flowrate/min.)	22	L.
Sucção até (Suction depth)	7	m.
Pêso líquido (Weight of liquid)	13	kg.



Peca n.º 1 - Prato (Plate)
2 - Corpo (Body)
4 - Alavanca (Handle)
6 - Anel suporte alavanca (Support ring)
9 - Corpo do pistão (Piston body)
10 - Porca do pistão (Piston nut)
11 - Válvula do pistão (Piston valve)
13 - Haste do pistão (Piston rod)
24 - Pêso da válvula (Valve weight)
40 - Manga de couro (Leather sleeve)
42 - Válvula de couro p/ prato
(Leather valve for plate)

Figure 9

MARUMBY (BRAZILIAN) PUMP

In addition to the above-mentioned comparative pumps, six U.S.-manufactured Robbins and Myers "Moyno" hand pumps were purchased and installed in Nicaragua during July 1978. The "Moyno" rotary, rotor and stator, positive-displacement pump has been developed just recently and shows considerable potential for use in rural developing countries. The "Moyno" pump is advertised as a positive-displacement, steady-flow, self-priming, simple-design, abrasion-resistant, and energy-efficient pump that requires minimal maintenance and has many components that could be locally manufactured in a developing country. (See following pages for "Moyno" brochure information in more detail.)

The "Moyno" pumps installed in Nicaragua were installed in deep wells of between 40 and 70 feet with usage by between 300-500 villagers. The cost of the six pumps was $400 each, plus packing and shipping, for an average total unit cost of $470. Specific locations of the installed pumps were as follows:

1. Santa Teresa
2. Laguna de Los Hernandez
3. Valle de Santa Rosa
4. El Quebracho
5. Las Delicias
6. Los Pozos

Unfortunately, because of serious civil disorder that began during the latter months of this project and is still continuing in Nicaragua, project personnel were unable to install, inspect, or monitor these pumps, and thus, only limited information is available. It is known that the pumps were installed and initially performed well. However, in recent telephone calls to the Ministry of Health, it has been learned that five of the six "Moyno" pumps are inoperative. In one of the five cases, the villagers had operated the pump handle in a counterclockwise direction, which had loosened the rotor and stator from the plunger rod. In the other four cases, Ministry of Health personnel reported that the pumps had been "incorrectly installed," but did not give details as to what had been incorrectly done. Robbins and Myers states that the plunger rod and drop pipe must be of equal lengths, and this could possibly be the incorrect installation procedure to which they refer.

The Dempster pump used in the field test cost approximately $257 in Central America, the Brazilian "Marumby" approximately $45, and the IDRC pump about $70 (this estimated $70 cost was for comparison only and can vary widely,

Figure 10

THE MOYNO PUMP

Robbins & Myers
Fluids Handling Products

Bulletin 678

Hand Pumps for Rural Water Systems

Easy operation, minimum maintenance, maximum life

Figure 10 (continued)

Minimum maintenance, maximum life per unit of cost

The Robbins & Myers hand pump design eliminates the trouble spots found in most conventional hand pumps:

No Stuffing Boxes

No Packing

No Gaskets

No Pins

No Pin Bushings

No Cup Seals

No Cylinder Valves

Ideally suited for dense population areas where a single pump must serve the needs of many people, or for rural schools and clinics, where dependability is a must.

Not a modified farmyard pump, but a pump designed from the well strainer up to meet today's requirements for high performance, year-in-year-out dependability, long life, and low maintenance.

For wells up to 300′ (90m) deep!

Advantages of the Progressing Cavity Pump Principle

Positive displacement
The progressing cavity pump incorporates a screw-like, single helix rotor turning within a double helix stator. This pumping principle gives positive displacement, with the head developed independent of the speed, and capacity approximately proportional to the speed.

Steady flow
Progressing cavity pumps provide steady, non-pulsating flows. There is no wasted motion . . . every turn of the handles delivers water.

Self priming
Progressing cavity pumps are self priming. Pumping action starts the instant the pump starts.

Simplicity of design
There is only one moving part in the pump elements and that is the rotor. There are no valves, valve seats, or cup seals to wear out.

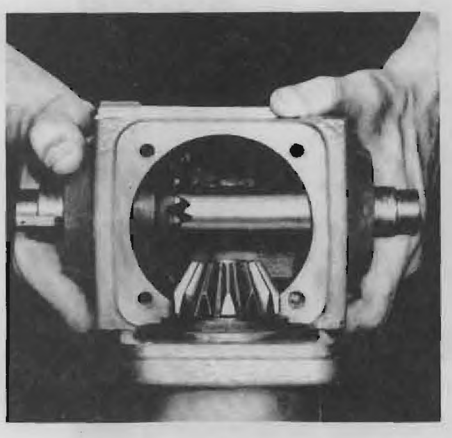
Abrasion resistant
The resilient stator material allows passage of abrasive sand or silt particles without damage to the pumping elements.

Energy efficient
Utilizing the mechanical advantage of the screw-like rotor, very little effort is required to operate the Robbins & Myers hand pump, even at depths of 300 feet.

Figure 10 (continued)

Designed for long life

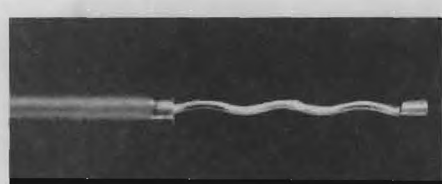
Pump stand fabricated from heavy steel plate and pipe. Will not crack or break during shipping or installation. Will withstand severe abuse in the most rugged operating conditions.



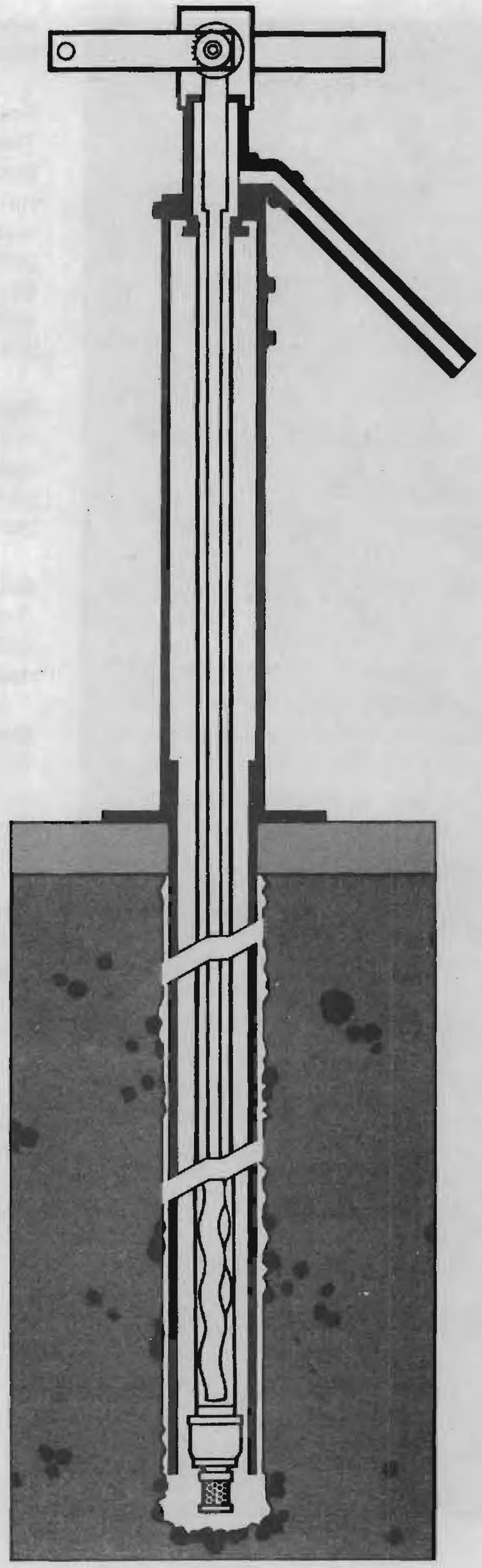
Heavy duty gearbox incorporates a right angle gear arrangement in a rugged housing. Gears are machined and hardened steel, mounted on high strength steel shafts. Tapered roller bearings provide precise gear alignment and long life. Sealed housing along with double lip seals on both handle and output shafts prevents lubricant leaking.

Rugged steel handle arms are keyed and bolted to the handle shaft. ⅞″ diameter handles permanently attached to handle arms.

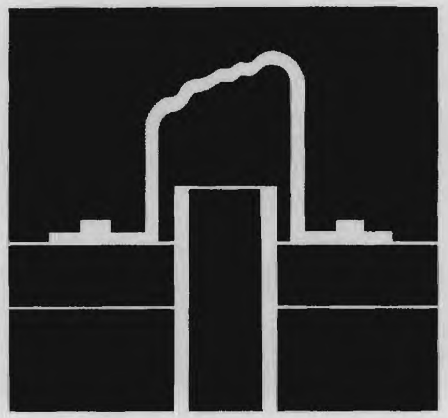
Special socket head bolts used throughout to minimize vandalism or pilferage.



Pumping elements designed to provide years of trouble free operation. The rotor is machined from alloy steel and plated for additional abrasion resistance and longer life; the stator utilizes a special low water swell elastomer, permanently bonded to a steel tube.



Sanitary design; easy installation



Tubular stand column fits over well casing extension (4" and smaller wells) to prevent sullage water from entering the well.

Pump stand completely sealed to prevent external contamination of the well.

Long, angled discharge spout prevents possibility of sticks and stones being dropped or forced into the well by mischievous children.

No stuffing box leakage since there is no stuffing box.

Dual sealing by means of a lip seal and a rotary seal on the drive shaft prevents lubricant leakage into the water supply.

Designed for ease of installation . . .
While unique in principle and design, the Robbins and Myers hand pump is simple to install. As with most other types of pumps, the pump cylinder and appropriate lengths of drop pipe and pump rod are lowered into the well and then fastened to the discharge housing and drive shaft.

Installed with conventional hand tools
When drop pipe and pump rod are furnished by Robbins and Myers, no field cutting and threading are required.

Designed for low "Total Life Cycle" cost
One of the most common mistakes in hand pump programs throughout the world has been the use of "initial price" as the basic criteria in hand pump selection. This "least cost technology" approach has led to failure rates of 30-80% and has defeated the goal of providing reliable sources of clean water.

A more realistic cost effective approach is "Total Life Cycle" cost, which takes into account not only initial price but the replacement part and maintenance costs over a 20 or 30 year period. This is the only method of determining the true cost of providing a dependable source of clean water.

While the "initial price" of a Robbins & Myers hand pump is higher than many pumps, long component life and maintenance-free design make it one of the most economical pumps on the market today from a "total life cycle" cost standpoint.

With the cost of the pump one of the lower costs in providing a village water system, it's worth spending a little more initially to assure year-in-year-out dependability and long life.

Figure 10 (continued)

Specifications

Pump Type
Progressing cavity (helical rotor); crank operated. Can be used as lift pump or force pump without modification.

Models
1V2.6 Single stage pumping elements For depths to 150′ (45m)

2V2.6 Two stage pumping elements For depths to 300′ (90m)

Well Diameters
Suitable for use in 3″ (7.5cm) diameter and larger well casings.

Weight
Pump Stand and Drive Assembly—114 lb. (52kg)

Pump cylinder-
Model 1V2.6—43 lb. (20kg)
Model 2V2.6—55 lb. (25kg)

10′ Well Extension Assembly—23 lb. (10.4kg)

Height
40″ (100cm) from base to handle centerline.

Turning force required on each handle:
Model 1V2.6—8 lb. (3.6kg) average
Model 2V2.6—12 lb. (5.4kg) average

Well extensions
Drop pipe, 1″ diameter galvanized pipe. Pump is easily modified to accept drop pipe of larger diameter. Pump rod, ½″ diameter steel rod with ½″-13 threads.

Performance curves

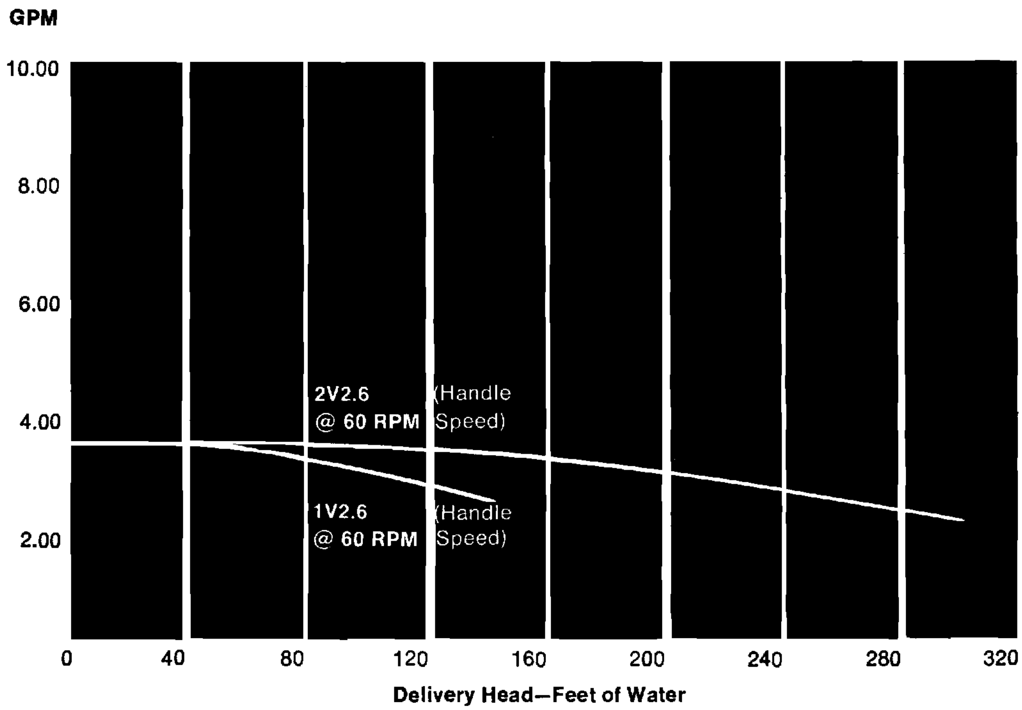


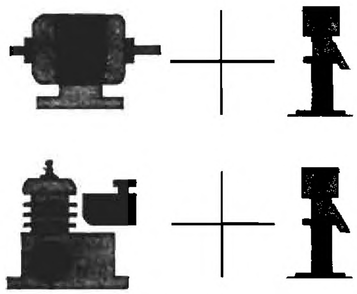
Figure 10 (continued)

Designed for quality

Robbins & Myers
Fluids Handling Products

Robbins and Myers Hand Pumps are built to the same rigid manufacturing standards and under the same quality control procedures as pumps supplied to the chemical, food, waste treatment, and petroleum industries.

Over 40 years experience in supplying engineered products to industry stands behind every Robbins and Myers Hand Pump.



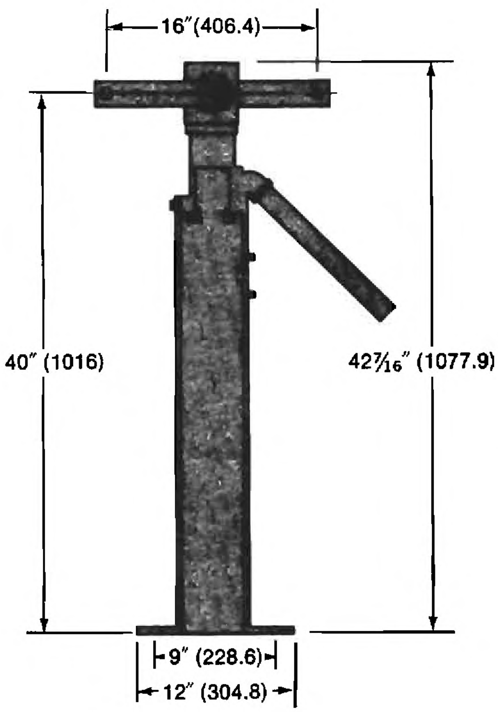
The Robbins & Myers Hand Pump can be converted to alternate power sources such as electric motors and gasoline engines. Please consult the factory for recommended conversions.

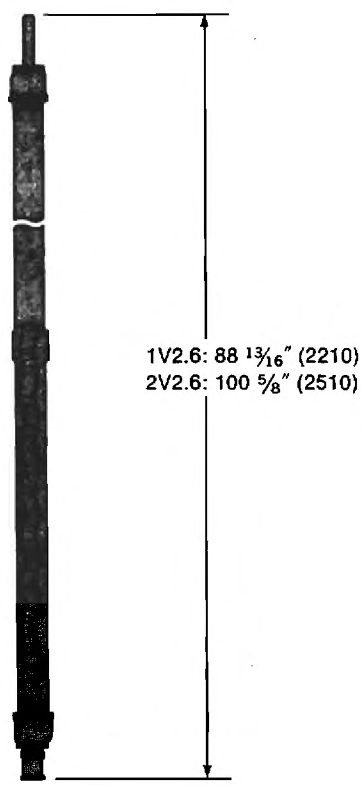
Pumps and Components manufactured in . . .

Springfield, Ohio U.S.A.
Columbia, South Carolina U.S.A.
Brantford, Ontario, Canada

Robbins & Myers, Inc.
Springfield, Ohio 45501
U.S.A.
Phone: (513) 327-3553

The Robbins & Myers Co. of Canada Ltd.
Brantford, Ontario N3T 5N6
Canada
Phone: (519) 752-5447





Bulletin 678 Litho in U.S.A.
2M-PS-878

depending on the materials and the pricing systems used by the fabricating shop). It is interesting, at this point, to recap all pumps included in the field testing of the AID pump, noting, as explained earlier, that price estimates for the manufacture of the AID pump vary greatly from country to country as well as from manufacturer to manufacturer within the same country.

	Costa Rica	Nicaragua
1. AID Shallow-Well (for shallow wells only)	$ 98	$ 69
2. Japanese "Lucky" (for shallow wells only)	63	--
3. Brazilian "Marumby" (for shallow wells only)	--	45
4. AID Deep-Well (for deep and shallow wells)	128	75
5. Dempster (for deep and shallow wells)	257	257
6. IDRC PVC Cylinder (for deep and shallow wells)	--	70
7. Robbins and Myers "Moyno" (for deep and shallow wells)	--	470

Another approach to analyzing the relative costs of the field-test pumps was to consider the total estimated material cost of installing each pump complete with drop pipe (average price @ $.70 per foot), plunger rod (average price @ $.71 per foot), drop pipe connectors (average price @ $.91 each), and plunger rod connectors (average price @ $1.06 each) at various depths. The Brazilian "Marumby" shallow-well pump extended to $63 for a 25-foot well. The Japanese "Lucky" shallow-well pump, when installed in a 25-foot well, cost $81. The AID shallow-well pump, installed at 25 feet, cost $87 in Nicaragua and $116 in Costa Rica. The Dempster pump for shallow or deep wells is a very good pump, but is expensive at $294 for a 25-foot well. The IDRC pump for shallow or deep wells was competitive in cost with the AID pumps used for deep wells (or shallow wells, if so desired). However, the cost data on the IDRC pump for this report are based on only one pump and do not give enough information for reliable conclusions. The "Moyno" pump is also expensive, ranging from a material installation cost of $515 (25-foot well) to $830 (200-foot well).

	25 ft.	50 ft.	75 ft.	100 ft.	150 ft.	200 ft.
AID Shallow-Well (C.R.)*	$116	$ --	$ --	$ --	$ --	$ --
AID Shallow-Well (Nic.)*	87	--	--	--	--	--
Japanese "Lucky"*	81	--	--	--	--	--
Brazilian "Marumby"*	63	--	--	--	--	--
AID Deep-Well (C.R.)	135	172	210	251	324	398
AID Deep-Well (Nic.)	106	143	181	222	295	369
Dempster	294	331	369	410	483	557
IDRC (three-inch PVC cylinder)**	123	167	212	254	355	452
Robbins and Myers "Moyno"	515	560	605	650	740	830

*Cannot be used for depths of more than 25 ft.
**PVC priced @ $1.20 per foot.

Monitoring System

In Costa Rica, designated, responsible individuals in each test community were provided with simple, printed report forms designed to provide information covering community usage, pump physical condition, and functioning problems, if any. These forms were filled out every 15 days and mailed to an AID engineer in San Jose for analysis, who then reproduced them and turned the copies over to Ministry of Health representatives. If any of the returned forms indicated that repairs were necessary, a maintenance team was dispatched to correct the problems.

The monitoring system in Nicaragua was similar to that in Costa Rica, except that all pumps were inspected every 15 days by Ministry of Health engineers who were permanently stationed in the field and were responsible for the completion of the report forms as well as initiating any necessary repairs. Information included in the report forms was reviewed periodically by ICAITI and recorded on pump performance charts. All Nicaraguan test sites also were inspected by Georgia Tech and/or ICAITI approximately 10 times during the 12-month monitoring period.

Pump Performance

The Nicaraguan-manufactured AID pumps have been well received by the people installing, operating, and maintaining them. Because of confidence that the Ministry of Health has in the future potential of the AID pumps, an additional 100 have been ordered by the Ministry from the manufacturer for installation.

Two major maintenance problems with the AID pump (see Table 8) became apparent when installation of the pumps began. The most critical problem was that the deep-well pump cap's weakest point was where maximum stress was being applied by the handle fulcrum upon the pivot arm of the cap, causing the pivot arm to break off from the cap. This problem was partly the fault of the design and partly the fault of the manufacturer. Because of an indented contour of the top plate of the pump body, it was not possible to cast the pump body as specified by the drawings (the patterns for the pump could not be removed from the molding sand without destroying the mold). Therefore, the manufacturer eliminated the indented contour of the top plate of the pump and then did not have enough clearance between the pivot arm of the cap and the top of the pump body. In order to obtain a better fit between the pump cap and the pump body, the manufacturer milled away a fillet on the pivot arm, thereby leaving a notch at the point of maximum stress. To alleviate the entire problem, the pump cap was redesigned by lifting the pivot arm up and away from the pump body and positioning it so that it does not absorb so much of the stress caused by the downward force of the pump handle (the fulcrum handle also had to be shortened). (See Figures 11 and 12.) The redesigned cap was put into production at the manufacturer's foundry, installed on the pumps in the field, and has presented <u>no</u> additional problems.

The second major maintenance problem encountered with the AID pump in Nicaragua evolved when the manufacturer could not find 3-inch inside diameter PVC pipe for the deep-well cylinders. As a result, the manufacturer used 3-inch outside diameter PVC pipe and expanded it, by heating, to a 3-inch inside diameter. Quality control for such an approach was most difficult, and the results were unacceptable. While several of these PVC cylinders were installed in the field, it was decided that metal cylinders coated internally with epoxy (a Battelle option) would have to be used until the correct size PVC could be made available locally or imported from another country. In July (1978) the correct size PVC pipe was obtained from a local manufacturer and cylinders were produced according to specifications to be used for future pump installations.

Table 8

FIELD TEST PUMP MAINTENANCE - NICARAGUA

Site No.	Location	Corrective Maintenance During Test Period
		A. AID DEEP-WELL PUMP WITH METAL CYLINDER
6	Las Mangas	Battelle design cap broken -- replaced with modified version 1 cup change (excessive wear) Cylinder replaced (excessive cup wear)
19	Los Hatillos	1 cup change (excessive wear) Cylinder replaced (excessive cup wear)
20	Los Hatillos	Battelle design cap broken -- replaced with modified version 1 cup change (excessive wear) Cylinder replaced (excessive cup wear)
22	Los Rincones	Battelle design cap broken -- replaced with modified version 1 cup change (excessive wear) Cylinder replaced (excessive cup wear)
23	Santa Rosa	4 cup changes (excessive wear)
24	El Jocote	3 cup changes (excessive wear)
		B. DEMPSTER DEEP-WELL PUMP -- BRASS CYLINDER
1	La Garita	NONE
3	La Lamilla	NONE
4	San Antonio	Worn-out pin connecting handle to plunger rod
9	Mechapa	NONE
11	Isidrillo	Broken piston rod union
13	El Rodeo	NONE
15	Los Calpules	NONE
16	Paso Hondo	NONE
		C. AID SHALLOW-WELL PUMP WITH METAL CYLINDER
10	El Naranjo	1 cup change (excessive wear)
12	La Concepcion	Pump cap replaced (broken -- casting defect) 3 cup changes (excessive wear)
14	Los Calpules	Pump cap replaced (broken -- casting defect) 5 cup changes (excessive wear)
18	Las Lajas	1 cup change (excessive wear)
26	Licoroy	Handle replaced (broken -- casting defect)

Table 8 (continued)

Site No.	Location	Corrective Maintenance During Test Period
27	Tomabu	Pump cap replaced (broken -- casting defect)
28	El Espinal	2 cup changes (excessive wear)
29	El Espinal	Pump cap replaced (broken -- casting defect)
	D. "MARUMBY" SHALLOW-WELL PUMP -- HONED METAL CYLINDER	
2	Las Lajitas	1 cup change (excessive wear)
5	Las Mesas	Cap replaced (broken)
8	San Diego	1 cup change (excessive wear)
17	Quebrada Arriba	Pump cap replaced (broken) 1 cup change (excessive wear)
30	Sabana Grande	Pump cap replaced (broken) 1 cup change (excessive wear)
	E. IDRC EXPERIMENTAL PUMP	
7	Llano Grande	NONE -- foot valve has tendency to stick and cause pump to lose its prime

Figure 11

MODIFIED DEEP-WELL PUMP CAP IN NICARAGUA

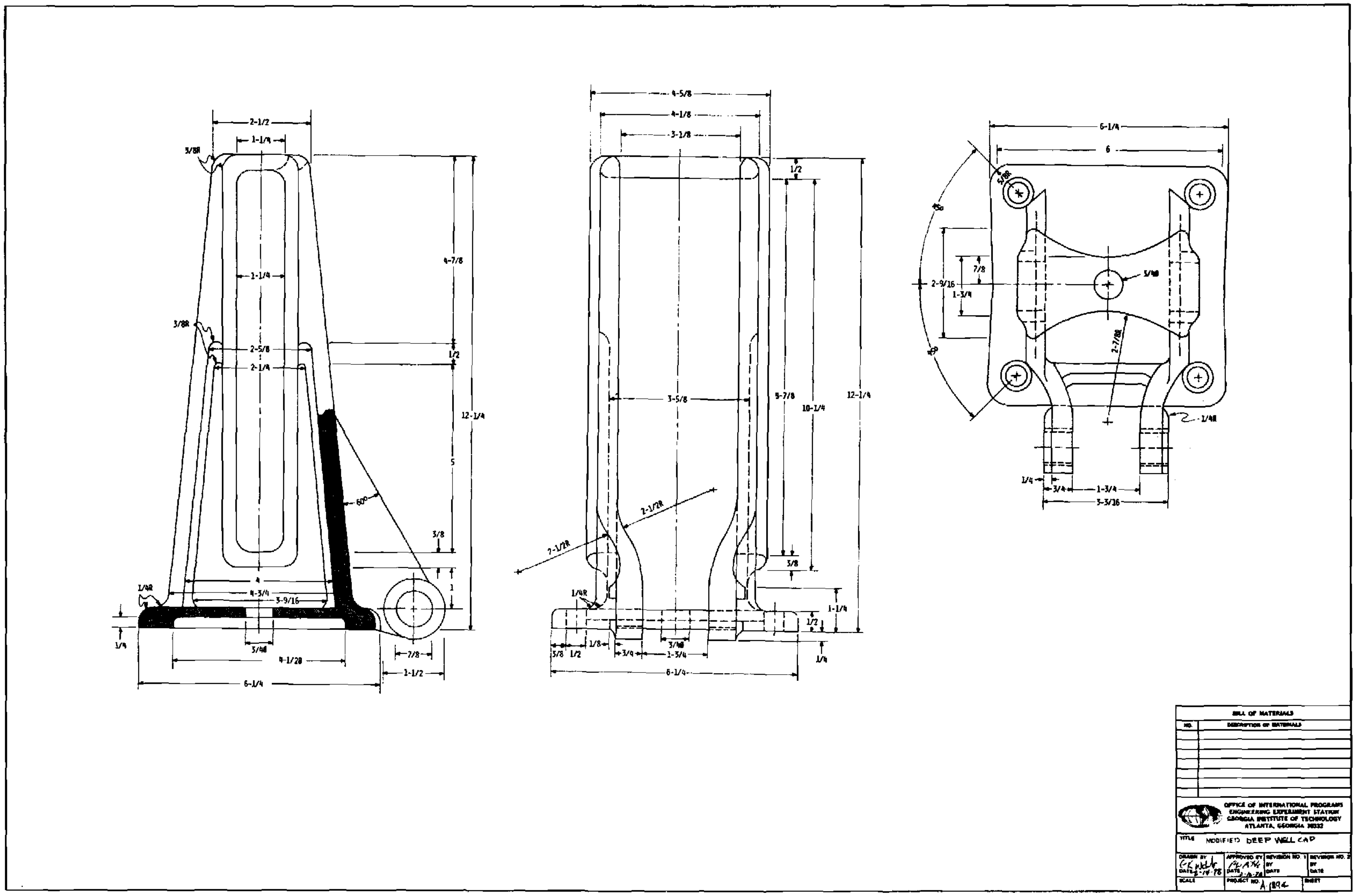
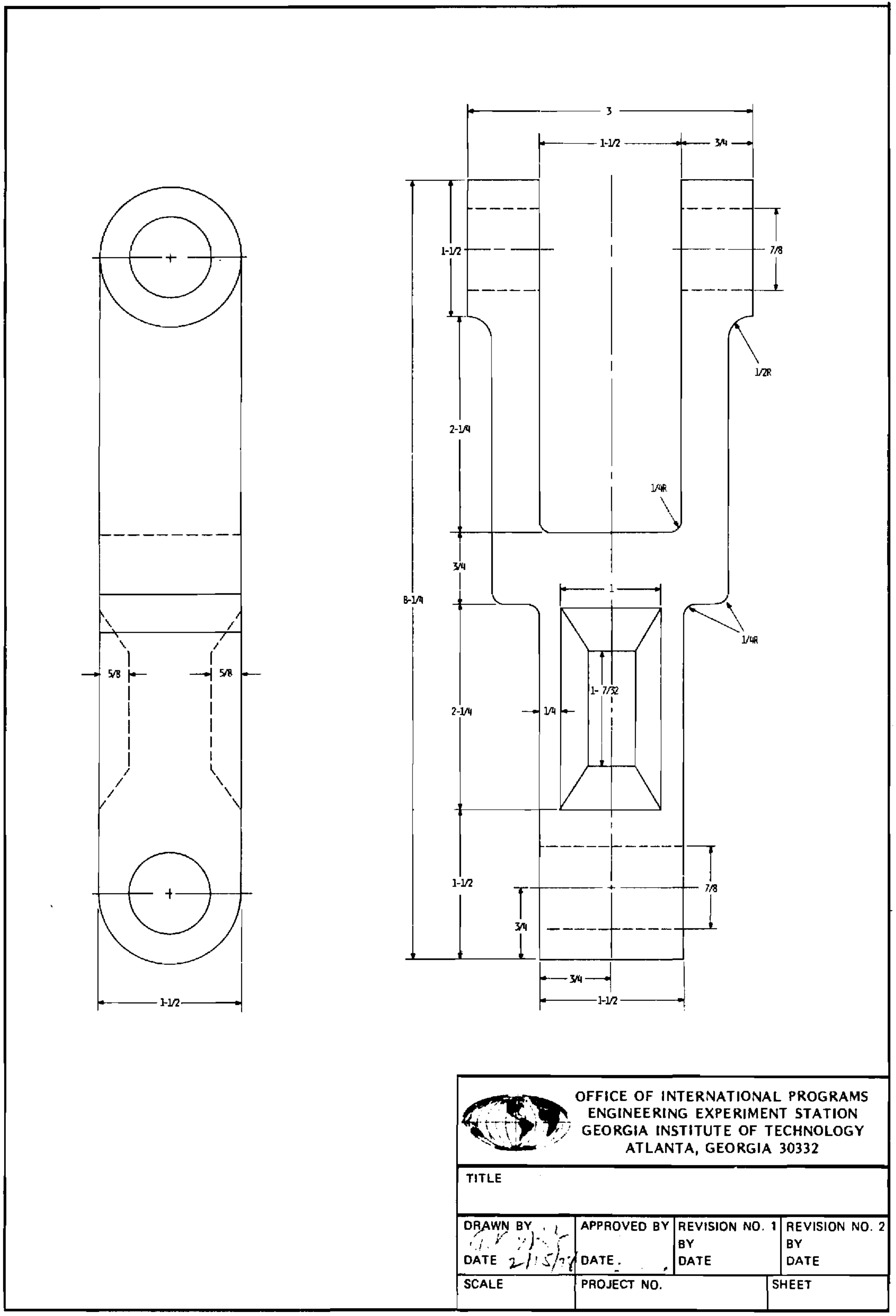


Figure 12

FULCRUM HANDLE FOR MODIFIED DEEP-WELL
PUMP CAP IN NICARAGUA



Excessive wearing of leather cups has also presented problems for the AID pump in Nicaragua principally because of insufficiently smooth cylinders and oversized cups. Battelle drawings specify a 3-inch diameter leather cup for a 3-inch cylinder, which would be satisfactory if leather did not expand when wet. To allow for expansion, the dry cups should have been made approximately 1/16-inch undersized. A replacement order for the original oversized cups was filled by the pump manufacturer, and the wearing of these new cups has been considerably less due to the use of a blanking tool that improves the quality controls of the manufacturer. The blanking tool has proven to be very beneficial and is being modified to resemble a method suggested by Dr. Eugene McJunkin in a recent publication:

> For "mass production," wooden forms can be used. To make the forms, use wooden boards about 3/4-inch (approx. 19mm) in thickness, having holes of the same diameter as the pump cylinders, and nailed to a stiff backboard. Cylindrical blocks, 3/8-inch (approx. 9.54mm) less in diameter, are bolted concentrically within the circular openings. The bolts should be long enough so that . . . wet and pliable leather, laid over the holes, can be drawn down by the bolts and blocks, forcing the leathers into position . . . let dry, remove and trim the wrinkled edge with a sharp knife (including the center hole), soak for 12 hours in a edible oil (preferably neat's-foot), wax, and lightly apply graphite grease to the wearing surface.1/

The Brazilian "Marumby" pump presented major problems. The weakest point of the pump appeared to be where the handle and the pump cap are connected. In three of the five pumps tested, the pump cap had to be replaced due to breakage at this point. Spare parts were also difficult to find for this pump, and the local distributor did not carry a large inventory of extra pumps for replacement purposes -- a factor that enhances the argument for locally manufacturing pumps so that spare parts can be made readily available.

The Dempster pumps in Nicaragua, as in Costa Rica, have had no major problems. The IDRC pump has performed relatively well, but has had some difficulty with its foot valve sticking in the open position (allowing the pump to lose its prime).

1/F. Eugene McJunkin, Handpumps for Use in Drinking Water Supplies in Developing Countries (The Hague, Netherlands: International Reference Center for Community Water Supply, 1977), p. 196.

Attempts also were made in Nicaragua to correlate the different well depths and the number of people using the wells with the amount of total stress exerted on the pumps. A direct correlation was made between actual force on the pump and the depth of the wells when the distance to the water level was taken into account. This was especially true when comparing the depth and forces of a particular pump (i.e., the Dempster). As in Costa Rica, friction obviously plays a tremendous role on the performance of the pumps (see Table 9).

In Nicaragua, water meters were installed in five sites to check the validity of usage estimates in a manner similar to that used in Costa Rica. Results indicated an average per capita consumption of approximately two gallons per person per day. This figure is almost twice as great as the per capita consumption determined for Costa Rica, probably due to the higher incidence of true community well sites in Nicaragua as opposed to the schoolhouse sites in Costa Rica. As was the case in Costa Rica, maintenance problems occurred randomly, and no correlation could be established between usage and corrective maintenance requirements.

Water Quality -- Bacteriological and Chemical

The results of chemical analyses of 19 potential sites prior to pump installation are given in Table 10. For comparison, the limits established by the World Health Organization are also included.[1/] An examination of the bacteriological data (Table 11) shows that all sites were significantly contaminated with common intestinal bacteria prior to pump installation. Salmonella was initially reported at Los Laureles, and this point was rechecked and found to be negative.

Because of the high level of bacteria found in the water in Nicaragua, all sites were to be analyzed further during the latter part of the project. This was to be done to provide more insight into whether or not contamination was being sealed off from the water by the preparation of the wells and the installation of the pumps. However, as reported earlier, Nicaraguan civil disorder during the latter part of 1978 prohibited such analysis.

[1/] International Standards for Drinking Water, Third Edition, published by the World Health Organization, Geneva, 1971.

Table 9

FORCE EXERTED ON FIELD-TEST PUMPS (NICARAGUA)
AS A FUNCTION OF WELL DEPTH

Depth (m)	Site No.	Actual Force Newtons	lb$_f$	Theoretical Force+ Newtons	lb$_f$	AF/TF*	Type of Pump
2.5	27	77.4	17.4	50.3	11.3	1.5	AID-SW
2.8	30	298.9	67.2	37.8	8.5	7.9	Marumby
2.9	12	129.0	29.0	45.4	10.2	2.8	AID-SW
3.1	10	129.0	29.0	54.3	12.2	2.4	AID-SW
3.5	28	258.0	58.0	51.6	11.6	5.0	AID-SW
3.8	14	129.0	29.0	57.4	12.9	2.2	AID-SW
4.7	17	199.3	44.8	48.9	11.0	4.1	Marumby
5.0	8	124.6	28.0	51.2	11.5	2.4	Marumby
5.0	26	77.4	17.4	66.7	15.0	1.2	AID-SW
6.0	29	311.4	70.0	74.7	16.8	4.2	AID-SW
6.7	18	206.4	46.4	64.1	14.4	3.2	AID-SW
6.9	2	154.8	34.8	144.6	32.5	1.1	AID-DW
7.6	16	587.2	132.0	148.1	33.3	4.0	Dempster
9.0	1	667.2	150.0	184.6	41.5	3.6	Dempster
9.5	15	667.2	150.0	187.7	42.2	3.6	Dempster
9.5	22	1083.6	243.6	181.5	40.8	6.0	AID-DW
10.2	21	645.0	145.0	188.2	42.3	3.4	AID-DW
10.4	4	693.9	156.0	205.5	46.2	3.4	Dempster
14.7	6	516.0	116.0	216.2	48.6	2.4	AID-DW
15.0	24	722.4	162.4	268.2	60.3	2.7	AID-DW
15.4	3	907.4	204.0	274.0	61.6	3.3	Dempster
17.1	13	800.7	180.0	288.2	64.8	2.8	Dempster
17.2	19	645.0	145.0	298.5	67.1	2.2	AID-DW
17.3	20	1057.8	237.8	309.6	69.6	3.4	AID-DW
18.8	9	1494.6	336.0	341.2	76.7	4.4	Dempster
26.1	11	1494.6	336.0	461.7	103.8	3.2	Dempster

*Note: Ratio of Actual Force to Theoretical Force.

+Theoretical force is related to the distance to the water level as well as the depth (the latter for only deep wells). For this reason, theoretical force in many cases is not directly proportional to well depth.

Table 10

SUMMARY OF WATER CHEMICAL ANALYSES[a] -- NICARAGUA
(BEFORE PUMP INSTALLATION)

Site No.	Location	pH	Hardness as $CaCO_3$	Alka-linity as HCO_3^-	Total Solids	Fe	Mn	Ca	NO_3^-	F	Cl	$SO_4^=$
1	La Garita	7.0	350	26	218	0.07	0.05	70.0	3.76	0.30	22.5	2.0
2	Las Lajitas	7.5	200	190	225	0.02	0.40	50.0	4.43	0.35	5.0	2.0
4	San Antonio	7.9	240	270	404	0.01	0.00	68.0	2.65	0.50	19.5	11.0
6	Las Mangas	6.4	100	100	38	0.02	0.00	20.0	2.21	0.50	15.0	2.0
7	Llano Grande	6.4	200	120	161	0.07	0.00	30.0	9.96	0.70	12.5	3.0
8	San Diego	7.6	260	290	398	0.10	0.00	56.1	2.35	0.40	25.0	15.0
9	Mechapa	7.7	325	30	330	0.06	0.00	80.0	13.10	0.40	12.5	8.0
10	El Naranjo	6.9	400	420	426	0.05	0.00	100.1	3.54	0.70	15.0	3.0
11	Isidrillo	7.6	400	180	100	0.07	0.00	90.0	306.50	0.35	62.5	10.0
14	Los Calpules (Stream)	7.9	290	330	394	0.01	0.10	80.0	0.00	0.55	10.0	2.0
15	Los Calpules (School)	7.9	210	200	237	0.01	0.00	50.0	5.10	0.60	12.5	4.0
17	Quebrada Arriba	7.5	180	280	360	0.10	0.28	44.1	1.76	0.20	15.0	8.3
22	Los Rincones	8.1	70	445	608	0.01	0.00	20.0	16.60	0.25	20.0	20.0
	Los Rastrojos	7.6	840	260	1,600	0.27	0.58	292.0	0.66	1.62	20.0	67.5
	Santa Teresa	8.1	240	265	383	0.01	0.00	62.0	9.52	0.35	15.5	11.0
	Los Laureles	7.7	250	265	340	0.01	0.00	64.0	6.42	0.60	15.0	6.0
	Rio Grande	8.0	190	250	336	0.25	0.28	52.1	4.80	0.20	25.0	10.5
	Motolin	8.2	240	250	298	0.05	0.00	62.0	22.40	0.65	14.0	4.0
WHO limits:												
	Highest desirable	7.0-8.5	100	--	500	0.10	0.05	75.0	(b)	(c)	200.0	200.0
	Maximum permissible	6.5-9.2	500	--	1,500	1.00	0.50	200.0	(b)	(c)	600.0	400.0

(a) All values mg/l except pH.
(b) Values above 45 mg/l considered potentially harmful, especially to children.
(c) Limit depends on daily air temperature. Upper limits range from 0.8 to 1.7 mg/l.

Table 11

SUMMARY OF BACTERIOLOGICAL ANALYSIS -- NICARAGUA
(BEFORE PUMP INSTALLATION)

Site No.	Location	Coliforms per 100 ml	Salmonella Presence	Shigella Presence	Comments
1	La Garita	2.4	Negative	Negative	Positive Enterobacter
2	Las Lajitas	150.0	Negative	Negative	Positive Enterobacter
3	La Lamilla	350.0	Negative	Negative	Positive Escherichia coli
4	San Antonio	120.0	Negative	Negative	Positive Escherichia coli
7	Llano Grande	430.0	Negative	Negative	Positive Enterobacter and Citrobacter
9	Mechapa	1,100.0	Negative	Negative	Positive Proteus and Citrobacter
10	El Naranjo	1,100.0	Negative	Negative	Positive Enterobacter
11	Isidrillo	1,100.0	Negative	Negative	None
13	El Rodeo	540.0	Negative	Negative	Positive Escherichia coli
14	Los Calpules (stream)	23.0	Negative	Negative	Positive Escherichia coli
15	Los Calpules (school)	920.0	Negative	Negative	None
22	Los Rincones	54.0	Negative	Negative	Positive Pseudomonas
--	Rio Abajo (Santa Teresa)	24.0	Negative	Negative	Positive Enterobacter
--	*Rio Abajo (Los Laureles)	64.0	Positive	Negative	Positive Salmonella sp, Enterobacter, and Citrobacter
--	*Rio Abajo (Los Laureles)	350.0	Negative	Negative	Positive Escherichia coli
--	La Majadita	64.0	Negative	Negative	Positive Escherichia coli

* This site (Los Laureles) was retested because of earlier findings of positive Salmonella. (Note: all tests performed in accordance with Standard Methods for the Examination of Water and Waste Water, 13th Edition APHA, 1971.)

INSTALLATION OF AID PUMPS

Installation of the AID shallow-well and deep-well hand pump is very similar to that of most reciprocating, single-action, positive-displacement shallow-well or deep-well hand pumps (for example, the Dempster, the Brazilian "Marumby," the Japanese "Lucky," and the IDRC pumps used in this program for comparative purposes). A three-man team that has installed a traditional, commercially available pump would most likely not have significant problems in the installation of the AID pump. Further, a three-man team that has never before installed a hand pump should become fairly proficient enough after installing five to ten AID pumps to install the AID pump in four hours, provided it has basic tools and expertise in cutting and threading pipe.

The AID shallow-well pump is installed by merely inserting 1 1/4-inch drop pipe into the well platform opening, attaching the threaded drop pipe to the base of the pump, and then securing the pump to the well platform. The length of the required drop pipe is determined by measuring the depth of the well with a weight and string from the well platform, allowing approximately two feet for mud at the bottom of the well if it is new or one foot if it is an older well where the mud has settled.

The AID deep-well pump is somewhat more difficult to install. The following steps are necessary:

1. Determine the length of required drop pipe by measuring the depth of the well from the well platform, allowing for the length of the cylinder which must be connected to the drop pipe and approximately two feet at the bottom for a new well or one foot for an older well.

2. Attach a six-inch section of drop pipe to the bottom portion of the cylinder.

3. Attach a full length of plunger rod to the plunger assembly inside the cylinder and replace the cylinder cap; then attach a full length of drop pipe to the cylinder.

4. Alternate the attaching of full-length plunger rod and drop pipe until the required length of drop pipe is secured (pay no attention to the length of the plunger rod).

5. Shove plunger rod entirely up through pump body, adding additional plunger rod if necessary, and attach the drop pipe to the pump stand.

6. With the plunger assembly resting at the bottom of the cylinder, there should be approximately three inches of plunger rod left sticking up through the pump cap to be threaded and attached to the pump cap.

7. Secure the pump stand to the well platform.

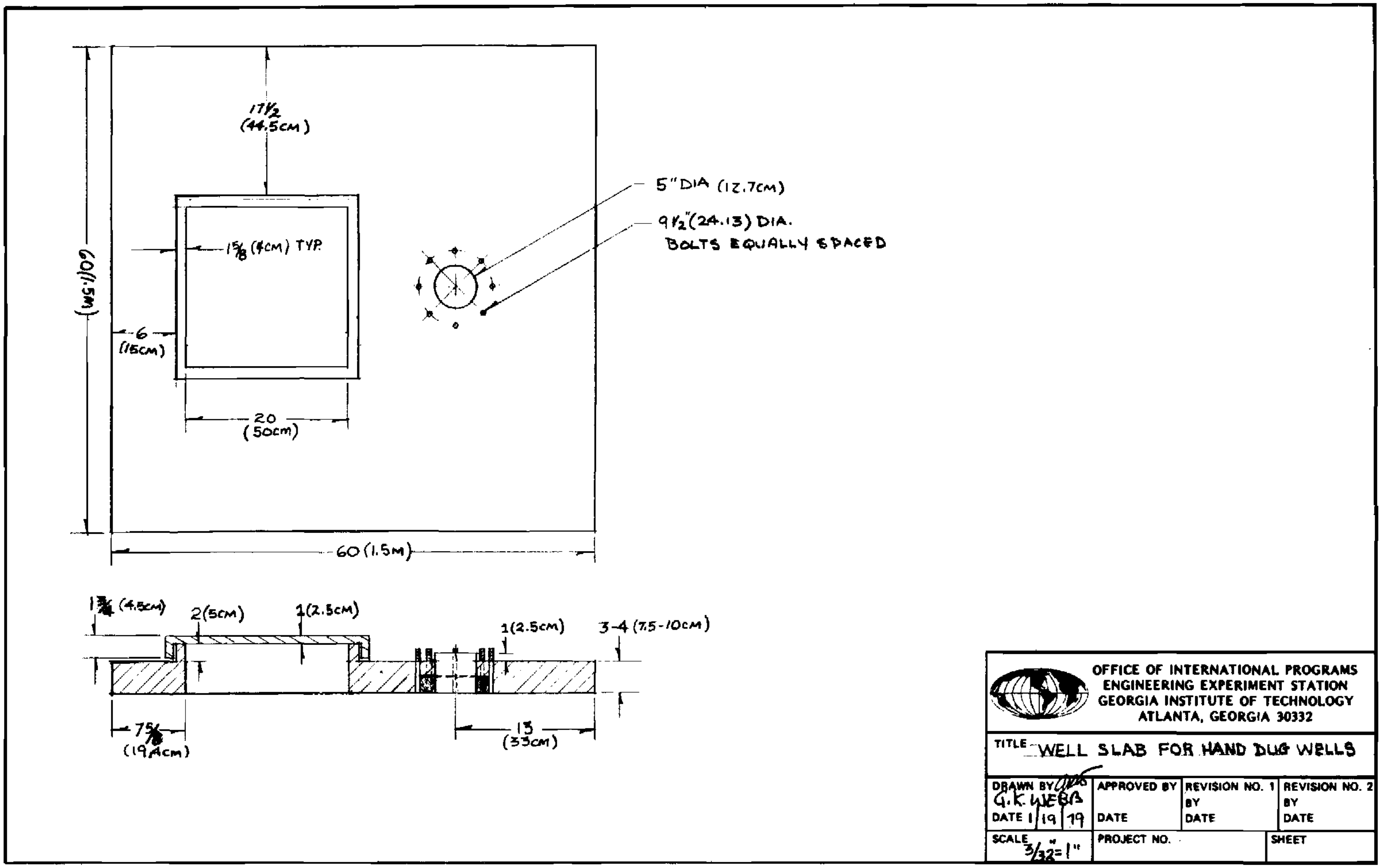
In regard to maintenance and repair, any water system, including one using hand pumps, must include a field maintenance support system, for no pump can last indefinitely without proper maintenance. Project personnel have seen numerous examples where good pumps are in excellent condition after many years (up to 10 years or more) of hard usage if minimally maintained, yet the same make and model pump can also be seen to be completely worn out in less than one year and unsalvageable if not properly taken care of. There is no such thing as a maintenance-free pump.

This field maintenance support system requires the training of technicians at a fairly sophisticated level where regional or centralized maintenance teams with adequate logistics, personnel, and budgets can support a hand-pump program. Training also is needed at a lower level of expertise to enable local villagers to handle simple, but important, tasks such as lubricating pumps on a weekly basis, repairing concrete well structures as necessary, painting exposed pump parts to prevent rust, and reporting to the regional or centralized maintenance teams if major problems exist.

The importance of a proper well structure cannot be overemphasized. The structure must not only be strong enough to support the pump and its users, but it also must be capable of keeping out all sources of possible contamination of the well water. (The following drawing depicts a suggested structure for hand-dug wells.) In addition, the structure should have a sloping apron at least 10 feet in diameter with raised edges and a drainage trough at least one foot in width to drain excess water at least 20 feet away from the apron to a natural drainage point.

Figure 13

WELL SLABS FOR HAND DUG WELLS



CONCLUSIONS AND RECOMMENDATIONS

Monitoring of pump performance has been conducted by Ministry of Health, AID, ICAITI, and Georgia Tech personnel. Despite many field test problems with the AID hand pump, field test results indicate that the AID pump can be manufactured with a high degree of quality in many less developed countries (LDCs). The test results, further, would most definitely encourage the manufacture, installation, and use of the AID hand pump in LDCs as a cost effective option.

The AID pump can be manufactured in a developing country at a competitive, profitable price and at an acceptable level of quality if adequate facilities (foundries, pattern makers, machine shops and skilled machinists, raw materials, etc.) are available; however, the availability of adequate foundry facilities with acceptable pump prices and quality controls must be determined for each individual developing country. Public acceptance by rural villagers has been good, in terms of both aesthetics and ease of use by men, women and children. Further, the AID pump should have a positive impact in LDCs on the health of rural people, employment generation, and foreign exchange requirements. In addition, the demonstration of local capabilities for manufacturing a rather complicated product instead of importing it should enhance the national pride of the people.

While numerous manufacturing problems, especially quality control, have been encountered in both Costa Rica and Nicaragua, the majority of these problems have been such as to be expected when a technological product like the AID pump is introduced into LDC production for the first time. As subsequent orders are processed through the manufacturer's plant and as personnel become more familiar with the pump itself, quality control should be refined to the point where the orders are considered to be normal production. All manufacturing problems were satisfactorily overcome as a result of adaptation and modification designs which ultimately proved to be workable in the LDC environment.

Pump Performance -- Costa Rica

Casting defects from the original order processed through the Costa Rican manufacturing plant for AID pumps caused shallow-well pump caps, handles, and one handle fulcrum to break. As subsequent orders for replacement parts were filled, these casting defects lessened in severity and no replacement part broke during the 12-month monitoring period. Even with serious casting defects in the modified deep-well caps, there were no breakages of this component, and project personnel (Ministry of Health, AID, ICAITI, and Georgia Tech) have agreed that the deep-well cap, including the stuffing box, also should be used on the shallow-well pump. (The stuffing box guides and prevents leakage around the plunger rod. The latter characteristic gives the pumps greater versatility, as it can then be used to lift water to an elevated storage location.)

The shallow-well pump in Costa Rica has consistently worn out leather cups because of the roughness of the walls of the metal cylinder. Since the Costa Rican deep-well pump with its PVC cylinder has worn out no leather cups during the 12-month monitoring period, project personnel recommend that the shallow-well pump should have a PVC-lined cylinder.

As a result of the above, Costa Rican Ministry of Health personnel have agreed to convert all existing shallow-well test pumps to deep-well pumps so that these pumps will give minimal maintenance problems in years to come.

Pump Performance -- Nicaragua

Problems with the AID pumps in Nicaragua have been numerous. The deep-well cap was originally manufactured as specified by Battelle drawing 2027 but with a positive draft angle on the front of the cap. The back of the pump cap then had to be notched out in order to fit the cap onto the pump body. Since this is the point where maximum stress is applied to the cap, breakage occurred when the pump was field tested. Subsequently, a redesigned pump cap was manufactured which has performed in a completely satisfactory manner.

Metal cylinders also have consistently worn out leather cups in both the deep-well and shallow-well Nicaraguan pumps. Replacement parts produced in Nicaragua have included PVC cylinders for the deep-well pumps, which should minimize cup wearing for this type pump. A formal recommendation has been made to Nicaraguan AID and Ministry of Health officials that all shallow-well pumps be modified to include PVC-cylinder liners and deep-well caps or changed to deep-well pumps complete with PVC cylinders. (Civil disorder within Nicaragua during final stages of this project has prohibited Georgia Tech/ICAITI personnel from personally implementing these suggestions.) These recommendations were made because of shallow-well cap breakage, even under relatively good casting conditions, and because of the excessive wearing of leather cups.

Recommendations for Future Use of the AID Pump

Based on experience in the field, the following specific recommendations are made for future use of the AID pump:

1. The AID deep-well pump should be equipped with either the modified Costa Rican deep-well cap (including stuffing box) or, preferably, the modified Nicaraguan deep-well cap. The Costa Rican deep-well cap has shown no signs of breakage or wear in over 12 months of testing, is simple in design and easy to manufacture, is lighter in weight than the Nicaraguan deep-well cap, but is not as sturdy. The Nicaraguan modified deep-well cap also has shown no signs of breakage or wear in over 12 months of testing, but is fairly complicated in design and, thus, more difficult to manufacture. It is heavier than the Costa Rican deep-well cap, and is extremely sturdy (a requirement necessary for wells where the water level approaches 75 feet or more below the top of the well or where daily usage of the pump is by more than 200 people).

2. The breakage problem of the Battelle-specified shallow-well pump caps can be eliminated in the future by merely using a deep-well cap on the shallow-well pump (either the Costa Rican or the Nicaraguan deep-well cap, neither of which has shown any breakage or wearing problems). Additional advantages of using the deep-well cap on the shallow-well pump are (1) it guides the plunger rod down in a straight motion that wears the leather cups evenly on all sides rather than in an arc that wears the cups, more or less, on two sides only, and (2) it eliminates the large, slotted opening of the shallow-well cap that seems to be a natural attraction for children to fill with rocks and small sticks.

3. It is imperative that cups of good quality and correct size be used and that the tendency to make oversized cups be avoided. Battelle specifications call for a 3-inch diameter leather cup for use inside a 3-inch inside diameter cylinder, which leads to an oversized cup when the leather becomes wet. The diameter should be reduced by at least 1/16 inch.

4. The use of hardened steel bushings in the pump handle holes that house hardened pivot pins is encouraged. The bushings should be at least

1/8 inch in thickness and hardened to approximately 60-64R_C. The pins should be hardened to approximately 40-45R_C.

In addition to the above, Battelle drawings specify that the holes in the handle pivot pin (where cotter pins hold the pump handle to the pump cap) should be 3 3/16 inches apart, plus 1/16 or minus zero inches; this specification should be 3 1/4 inches, plus 1/16 or minus zero inches, to ease insertion of the cotter pin and to prolong its use. Battelle drawings specify that the holes in the plunger rod pivot pin be 4 3/4 inches apart, plus 1/16 or minus zero inches; for the same reasons, this specification should be 4 13/16 inches, plus 1/16 or minus zero inches.

5. All cylinders should be PVC-lined. For the deep-well pump, this is no problem. However, the shallow-well pump should be modified by adding a PVC liner to the specified 3-inch inside diameter metal cylinder and decreasing the diameter of the plunger assembly proportionately to fit the reduced inside diameter of the liner.

6. Battelle drawings state: "Double cup plunger to be used when water level is more than 50 feet below surface." McJunkin reports, "A common practice is to use multiple cups in wells deeper than 100 feet (30 meters), adding a new cup every 50 to 100 feet (15 to 20 meters). The added head increases the slip (back flow) rate which multiple cups counteract by creation of a labyrinth type seal."[1/] The authors of this report randomly installed double cup plungers at various sites in Nicaragua and Costa Rica. In each instance where the double cup arrangement was used, cup life was extended. This appears to be feasible for wells of any depth; therefore, all future AID hand pumps should be installed with a double cup plunger assembly. For wells where the water level is more than 100 feet below the surface, an additional cup should be added to the plunger assembly every 50 feet.

Adding a PVC liner to the specified 3-inch inside diameter (galvanized iron) metal cylinder is relatively simple. The liner can be made from PVC pipe especially extruded to fit the metal cylinder snugly (no dimensions are given here because PVC and metal pipe vary slightly from one manufacturer to another and from one country to another). An easier method is to use PVC

[1/] Handpumps for use in Drinking Water Supplies in Developing Countries (The Hague, Netherlands: International Reference Center for Community Water Supply), 1977, p. 917.

with an outside diameter slightly larger than 3 inches (for instance, 3 1/4 inches) and an inside diameter slightly smaller than 3 inches (for instance, 2.95 inches), then to turn the outside diameter down to the desired size on a lathe. (The latter is being done in Indonesia for a program similar to the one described herein for Costa Rica and Nicaragua. It again should be noted that the change in the inside diameter of the cylinder caused by adding a PVC liner will require a proportionate change in the size of the leather cup and the plunger assembly.)

Appendix 3 shows working drawings of the recommended final design for the AID hand pump with modifications that have come about during the field-testing period. The drawings contain no patent limitations and are for the use of the general public.

Economies of the AID Pump

From an economic standpoint, the AID pump can be competitive in price with foreign imports into a developing country. It offers stimulation of small-scale industry (employment generation) as well as a contribution to a favorable balance of trade for the developing country. During this program, for a 25-foot well, the AID shallow-well pump cost $87 (including drop pipe, plunger rod, and connectors) in Nicaragua and $116 in Costa Rica. The AID deep-well pump cost $106 in Nicaragua and $135 in Costa Rica. The Japanese "Lucky" pump cost $81 in Costa Rica (not available in Nicaragua). The Brazilian "Marumby" pump cost $63 in Nicaragua (not available in Costa Rica). The IDRC pump cost $123 (installed only in Nicaragua). The Dempster cost $294 in both Nicaragua and Costa Rica, while the "Moyno" pump cost $465 in Nicaragua (not installed in Costa Rica).

Comparative Pumps

Comparative pumps used in the field test were originally chosen because they were expected to hold up well during the test period and because they were locally available. The Dempster pump is an excellent pump and has performed remarkably well, but is rather expensive when compared with the cost for which an AID pump can be locally manufactured. The Brazilian "Marumby" pumps have performed in an unsatisfactory manner and have been disappointing in their durability. The IDRC pump has good points that represent a lower level of manufacturing technology than that required of the AID pump, and is especially useful where foundry facilities are not available but local manufacturing is desirable. The Japanese "Lucky" pump has performed extremely well but, with no spare parts available in Costa Rica, undoubtedly will present maintenance problems as the components begin to wear. The "Moyno" pump is relatively expensive, but has the potential for a significantly positive impact on the health of developing countries. It appears to be capable of performing for a long period of time with little maintenance and has components that perhaps can be manufactured locally.

General Observations

The following general observations are offered from the experience of field testing the AID pump:

1. No matter how well a water pump is designed and manufactured, precise care and attention also must be accorded to the preparation of the well structure, the disinfection of the well water, pump installation techniques, training of local caretakers and follow-up maintenance.

2. A proper local governmental infrastructure must exist if a rural water system program is to be effective. This infrastructure requires people qualified to plan, organize, finance, purchase, engineer, install, maintain, monitor the use of the components of the system and train local community personnel in simple maintenance techniques.

3. There is no substitute nor shortcut to proper pump testing before starting on large operational programs. The world is full of broken pumps that have been hurriedly designed and placed into mass production without sufficient, if any, laboratory testing, field testing, and redesign, if necessary. While it is believed that the AID pump design is sound, each country considering the use of the pump should first investigate the local resources for manufacturing it and then carry out a brief program to field test the capabilities of the manufacturer and to work out unforeseen manufacturing problems.

4. Much is published about the necessity for maintenance of pumps. However, little information has been made available concerning maintenance of water quality in rural situations. The authors would like to see more research into bacteriological analysis of well waters over long periods of time to determine how effectively properly designed well structures seal out

contamination and how often wells should be redisinfected (different wells obviously should require more, or less, frequent disinfection, depending on their individual environment). This matter has been discussed with various AID and local government officials, but no evidence has been found where periodic redisinfection is carried out after a pump is installed (except, perhaps, when a pump is pulled from the well for maintenance and then reinstalled) even if chlorine is available.

5. The advantages and benefits of using a locally manufactured pump (like the AID hand pump) should not be underestimated. It is often quicker and easier to import a pump from another country, but this approach ignores in-country employment generation, readily available spare parts, savings in transportation, flexibility in design to meet local conditions, probable lower purchasing costs, and reduced foreign exchange requirements which free in-country money for other priority needs.

Final Evaluation

The Georgia Institute of Technology evaluation team finds the AID modified hand pump designs to be low in manufacturing cost and locally manufacturable in most LDCs. The pumps exhibited excellent operation and maintenance characteristics in Nicaraguan and Costa Rican field tests, and the designs proved to be readily usable and culturally acceptable in all field situations where they were introduced.

Much detailed work is involved in initiating local manufacture of a pump such as the AID model in LDCs which are not currently producing similar items. The manufacturer must be assisted in reaching a satisfactory level of quality control, and LDC implementing organizations must be made fully aware of the hand pump's capabilities and problems. This requires patient, prolonged and understanding work with personnel of a variety of private, governmental, and international organizations.

This project represents the application to LDCs of technology transfer in its most complete form. A methodology for working with indigenous manufacturers and cooperating organizations to stimulate the local fabrication, installation, and monitoring of the AID pump and other pumps has been devised and thoroughly tested. This successful methodology can easily be applied in a variety of countries interested in better hand pump equipment for their water supply and sanitation projects.

Appendix 1

COSTA RICAN TEST SITES

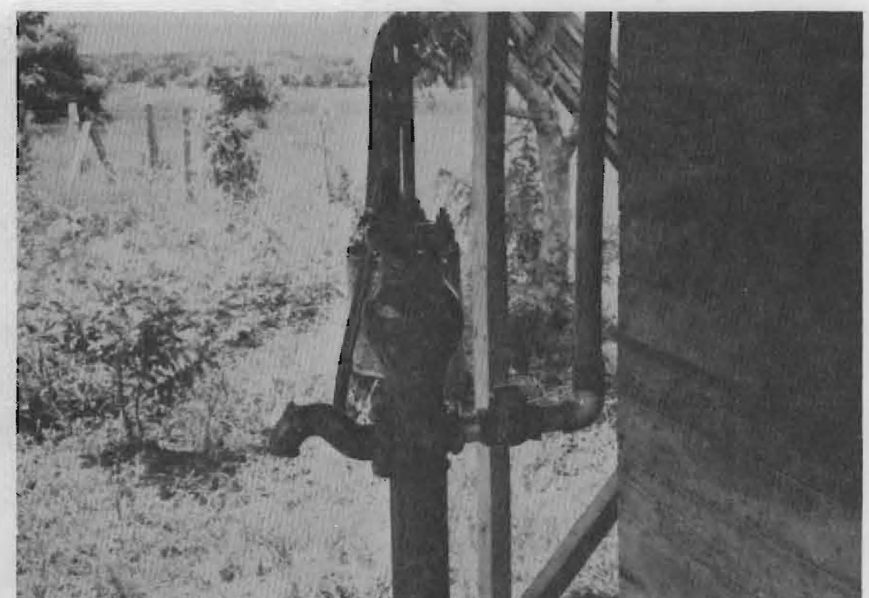
Site No. 1, located at La Palma de Abangares (AID deep-well pump).

Site No. 2, located at San Joaquin de Abangares (AID deep-well pump).

Site No. 3, located at IMAS, El Torito, Samara (AID shallow-well pump).

Site No. 4, located at Hernandez de Santa Cruz (Lucky shallow-well pump).

Site No. 5, located at Curime de Nicoya (Dempster pump).



Site No. 6, located at Pijije de Bagaces (Dempster pump).

Site No. 7, located at La Javilla de Canas (AID shallow-well pump).

Site No. 8, located at Zent, Matina school (AID shallow-well pump).

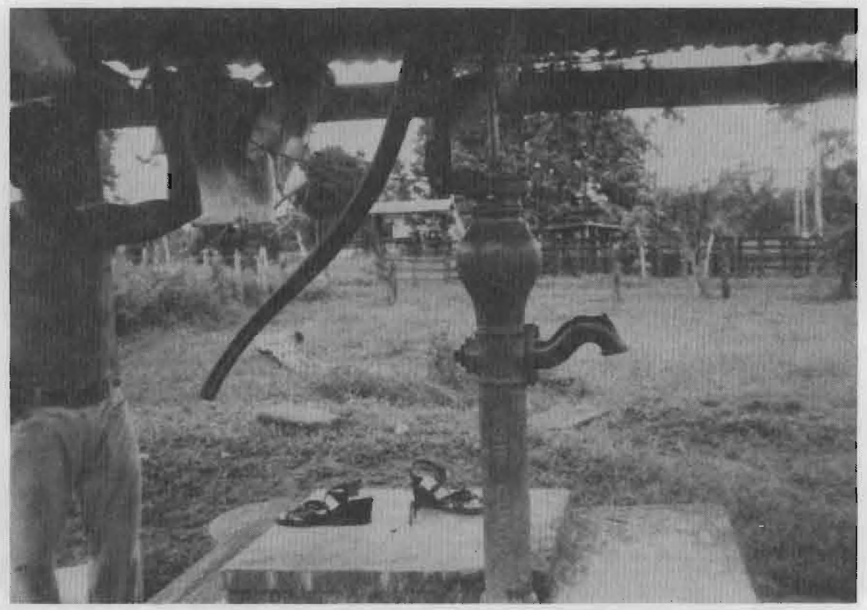
Site No. 9, located at Corina, Matina (AID shallow-well pump).

Site No. 10, located at Bristol, Matina (AID shallow-well pump).

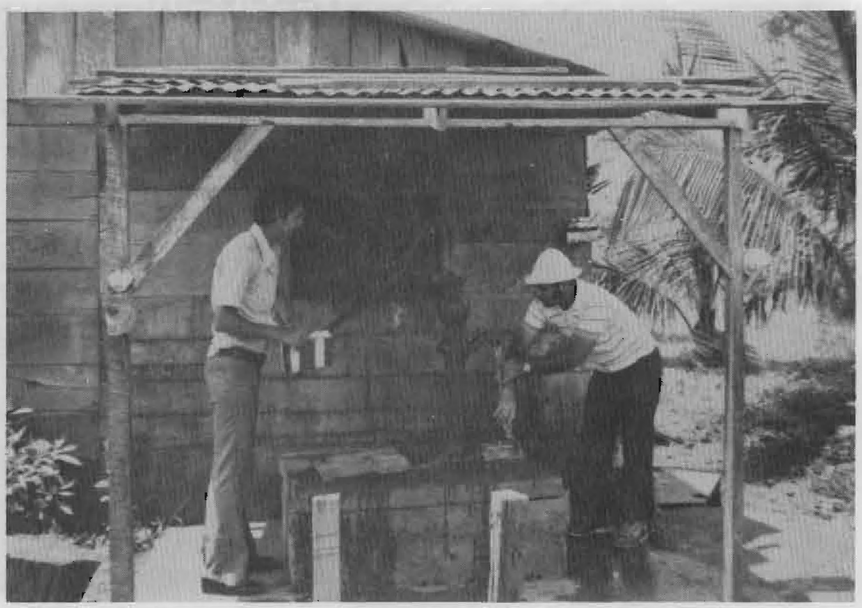
Site No. 11, located at La Margarita, Bataan (Lucky pump).

Site No. 12, located at Corazon de Jesus (Dempster pump).

Site No. 13, located at Zent, Matina (Lucky pump).

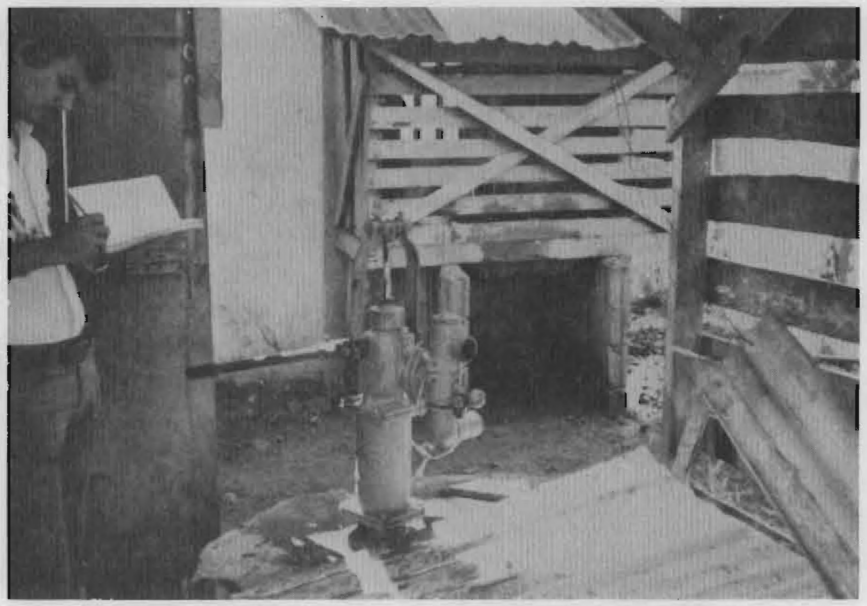


Site No. 14, located at San Miguel de Venado (Dempster pump).

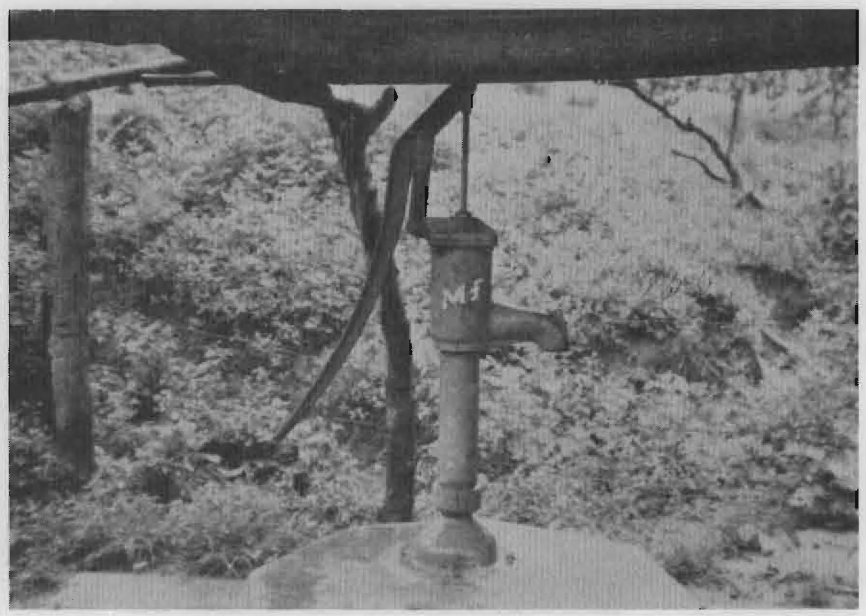


Site No. 15, located at Sabalito de Venado (Dempster pump).

Site No. 16, located at Pueblo Nuevo de Colorado (AID shallow-well pump).



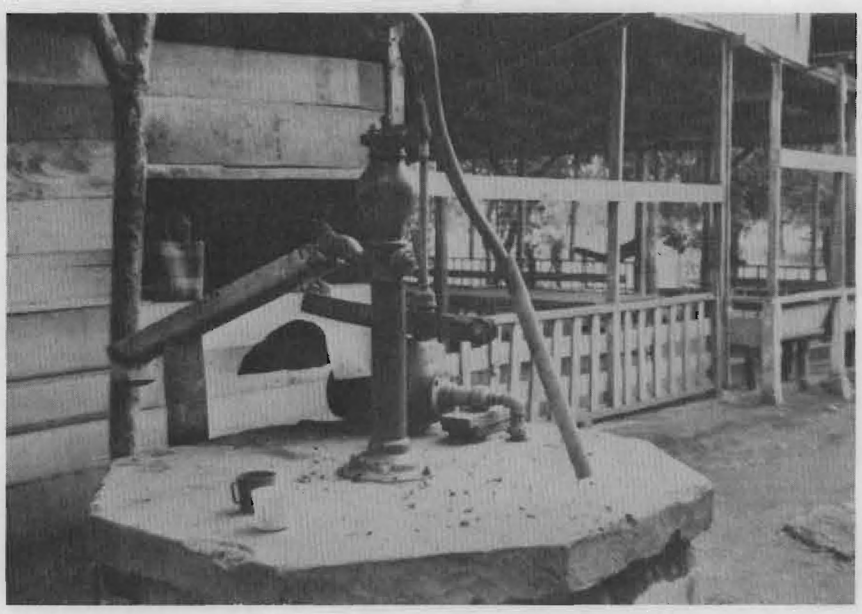
Site No. 17, located at San Francisco de Santa Cruz (Lucky pump).



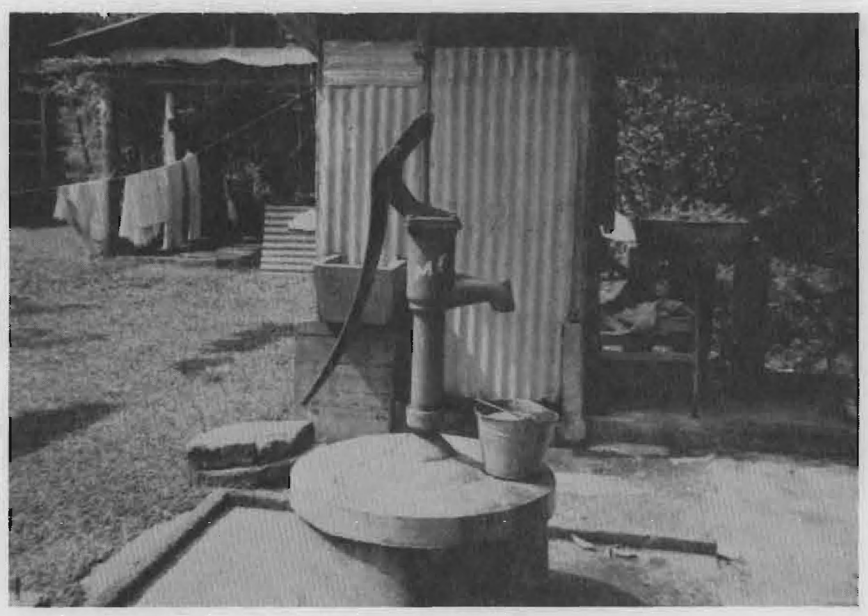
Site No. 18, located at Terciopelo de Nicoya (AID deep-well pump).

Site No. 19, located at Caimitalito de Nicoya (AID deep-well pump).

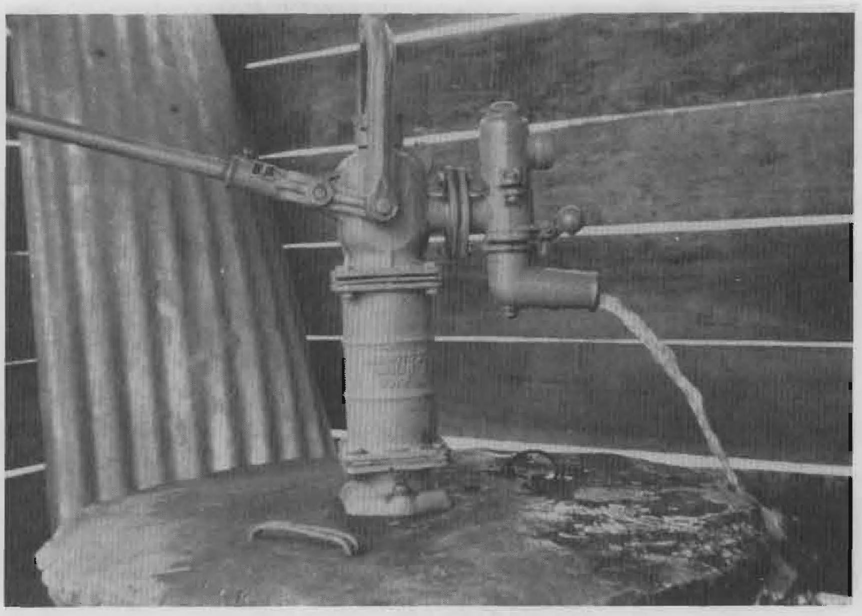
Site No. 20, located at Judas de Chomes (Dempster pump).



Site No. 21, located at Limonal de Abangares (Dempster pump).

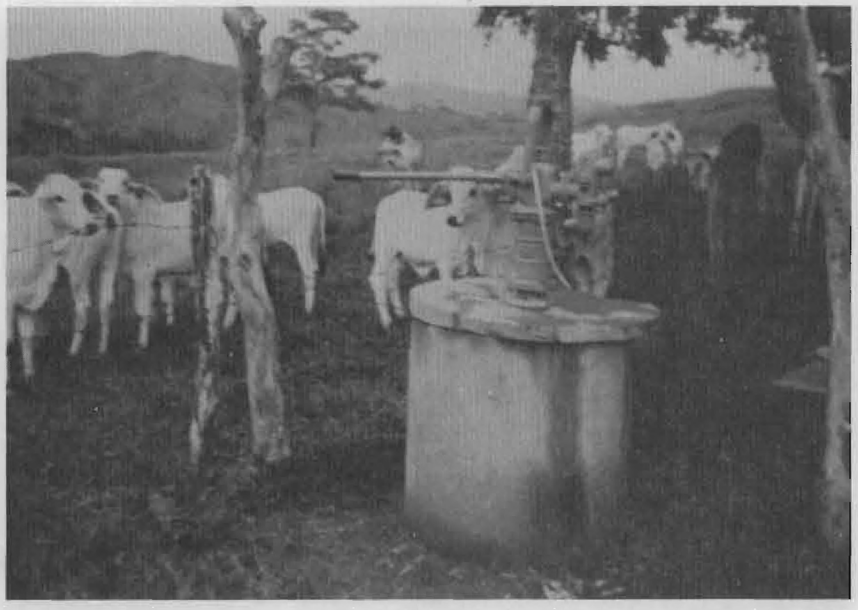


Site No. 22, located at Zent, Matina (AID shallow-well pump).



Site No. 23, located at Santa Marta de Matina (Lucky pump).

Site No. 24, located at Tarcolesa de Orotina (Lucky pump).



Site No. 25, located at Mesetas Abajo (Lucky pump).

Site No. 26, located at San Juan Grande (AID deep-well pump).

Site No. 27, located at Sabana Grande (AID deep-well pump).

Site No. 28, located at Cuyolito de Santa Cruz (AID deep-well pump).

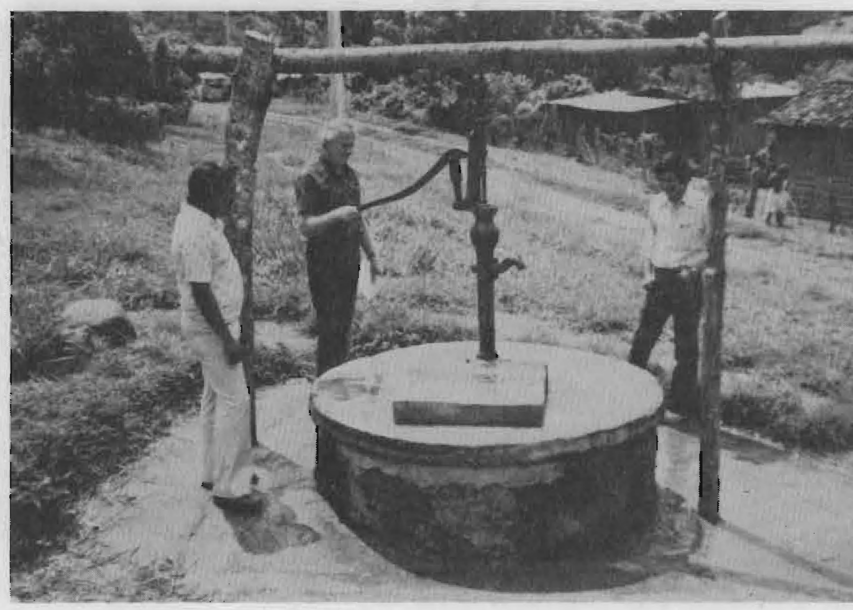
Site No. 29, located at La Lorena de Santa Cruz (Dempster pump).

Site No. 30, located at Lajas de Canas (AID deep-well pump).

Site No. 31, located at Indiana Tres-Siquirres (AID shallow-well pump).

Appendix 2

NICARAGUAN TEST SITES



Nicaragua Site No. 1, located at La Garita (Dempster pump).

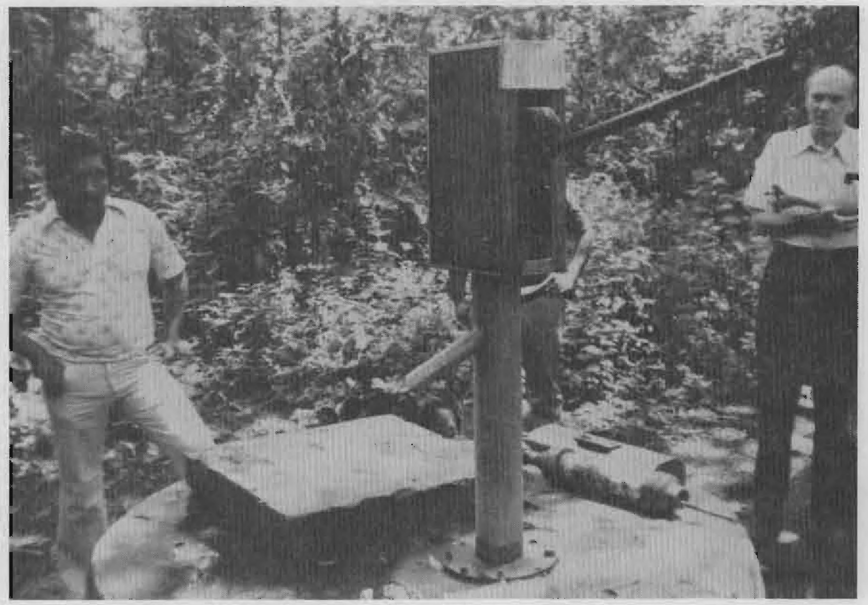
Nicaragua Site No. 2, located at Las Lajitas (Marumby shallow-well pump).

Nicaragua Site No. 3, located at La Lamilla (Dempster pump).

Nicaragua Site No. 4, located at San Antonio (Dempster pump).

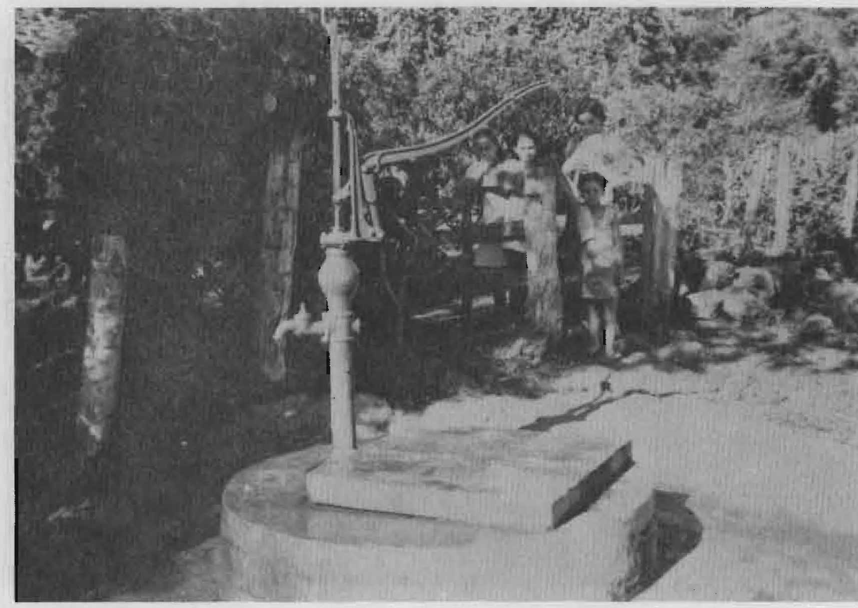
Nicaragua Site No. 5, located at Las Mesas (Marumby shallow-well pump).

Nicaragua Site No. 6, located at Las Mangas (AID deep-well pump).



Nicaragua Site No. 7, located at Llano Grande (IDRC pump).

Nicaragua Site No. 8, located at San Diego (Marumby shallow-well pump).

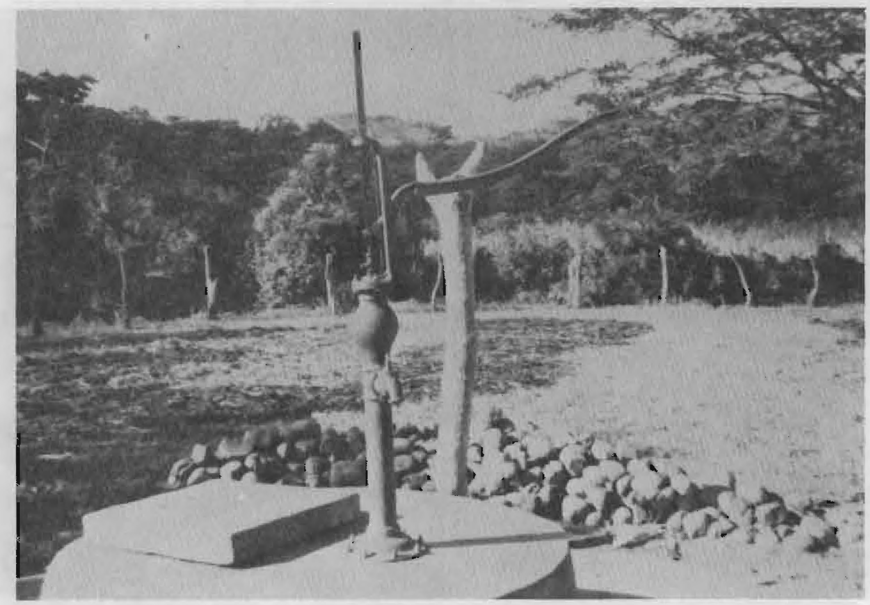


Nicaragua Site No. 9, located at Mechapa (Dempster pump).

Nicaragua Site No. 10, located at El Naranjo (AID shallow-well pump).

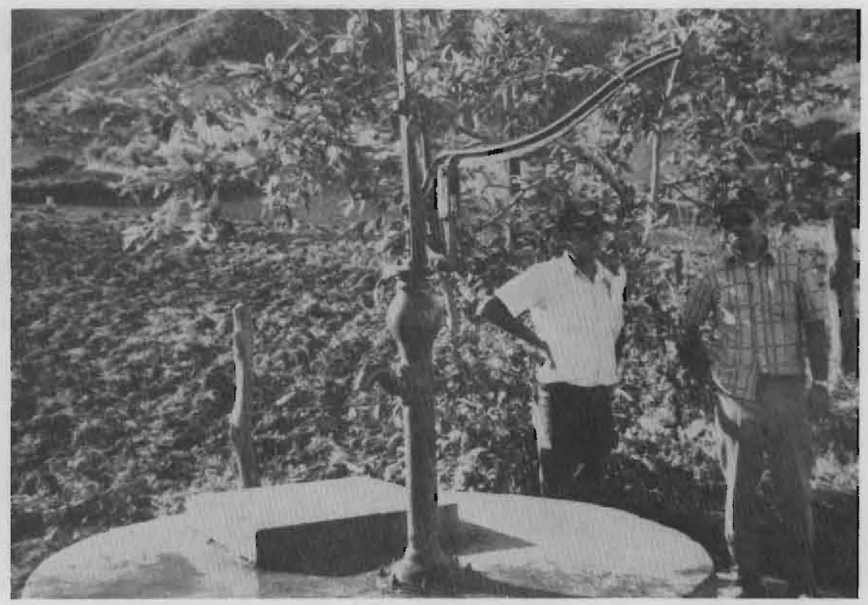
Nicaragua Site No. 11, located at Isidrillo (Dempster pump).

Nicaragua Site No. 12, located at La Concepcion (AID shallow-well pump).

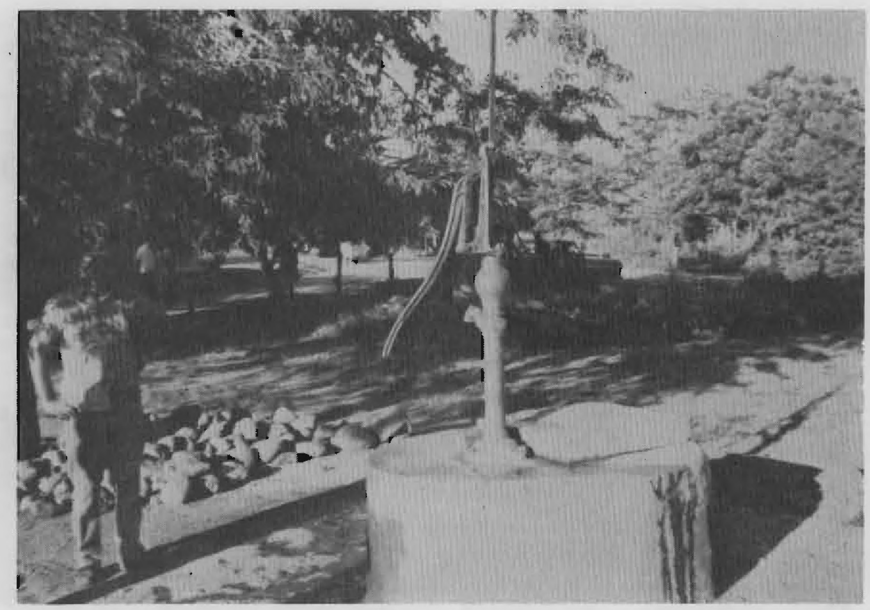


Nicaragua Site No. 13, located at El Rodeo (Dempster pump).

Nicaragua Site No. 14, located at Los Calpules stream (AID shallow-well pump).

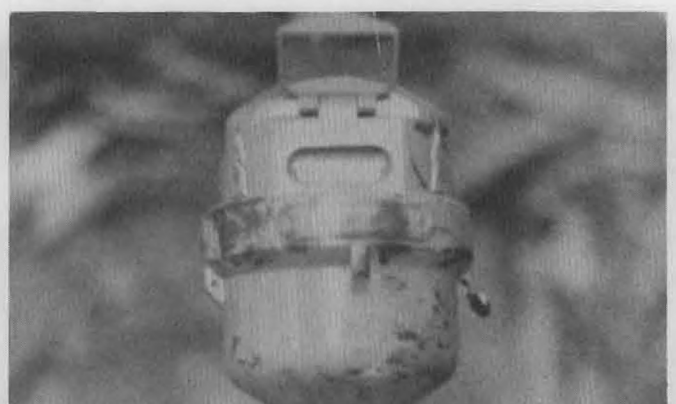


Nicaragua Site No. 15, located at Los Calpules school (Dempster pump).



Nicaragua Site No. 16, located at Paso Hondo (Dempster pump).

Nicaragua Site No. 17, located at Quebrada Ariba (Marumby shallow-well pump).



In order to better understand water consumption patterns of the users of test pumps, water meters have been installed at representative sites in both Nicaragua and Costa Rica. These water meters will accurately record the amount of water, in gallons, that passes through the pumps during a given period of time and will provide data to complement user figures based on village population. Sites having water meters, in Nicaragua, are Las Lajitas (Site No. 2), San Antonio (Site No. 4), Santa Rosa (Site No. 23) and El Espinal (Sites No. 28 and 29).

Nicaragua Site No. 18, located at Las Lajas (AID shallow-well pump).

Nicaragua Site No. 19, located at Los Hatillos community plaza (AID deep-well pump).

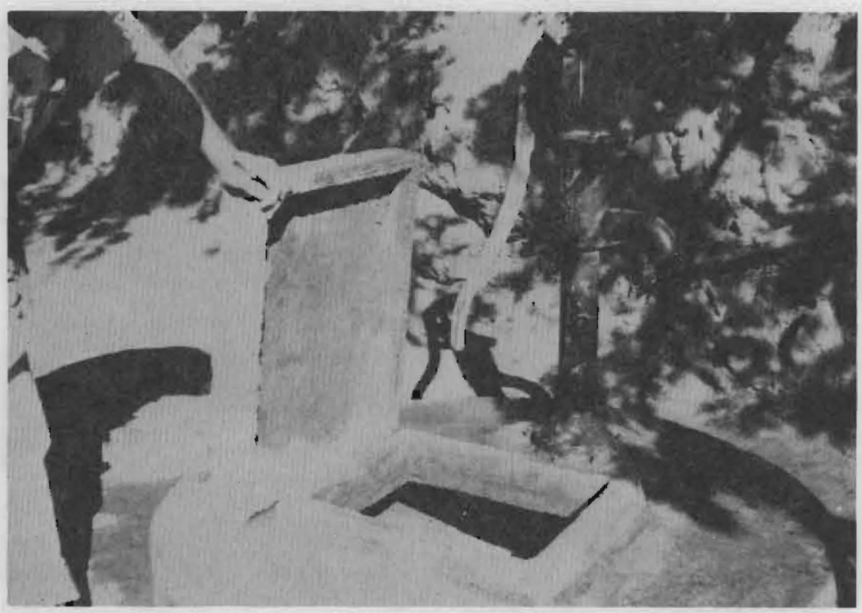
Nicaragua Site No. 20, located at Los Hatillos (AID deep-well pump).

Nicaragua Site No. 21, located at Musuli (AID deep-well pump).

Nicaragua Site No. 22, located at Los Rincones (AID deep-well pump).

Nicaragua Site No. 23, located at Santa Rosa (AID deep-well pump).

Nicaragua Site No. 24, located at El Jocote (AID deep-well pump).



Nicaragua Site No. 25, located at Mechapa-La Concepcion (AID shallow-well pump).

Nicaragua Site No. 26, located at Licoroy (AID shallow-well pump).

Nicaragua Site No. 27, located at Tomabu (AID shallow-well pump).

Nicaragua Site No. 28, located at El Espinal (AID shallow-well pump).

Nicaragua Site No. 29, located at El Espinal (AID shallow-well pump).

Nicaragua Site No. 30, located at Sabana Grande (Marumby shallow-well pump).

Appendix 3

AID/BATTELLE PUMP WORKING DRAWINGS

The following changes have been incorporated into the original Battelle hand pump drawings by the Georgia Institute of Technology under contract No. AID/ta-C-1354.

- Drawing 2001

  Option B showing a pin-mounted pump cap has been eliminated. Option C has now become Option B.

  The modified deep-well pump cap has replaced the shallow-well cap along with the corresponding fulcrum handle which has been shortened to 8 1/4".

  The double cup assembly has replaced the single cup assembly.

  Find numbers 19, 20 and 21 have been added to show the location of the short and long bushings as well as the long pivot pin.

- Drawing 2002

  Option B showing a pin-mounted pump cap has been eliminated.

  A modified deep-well pump cap has replaced the original one.

  The fulcrum handle has been shortened to 8 1/4".

  Find numbers 25 and 26 have been added to show the location of the short and long bushings.

- Drawing 2003

  An asterisk along with the words "Use 1/2 Dia if 7/16 Dia is unavailable" has been added.

- Drawing 2004

  The diameter of the through hole has been increased from 41/64" to 29/32".

- Drawing 2005

  The distance between pin holes has been increased from 3 3/16 plus 1/16 minus 0 to 3 1/4 plus 1/16 minus 0.

  In the Material & Treatment box, the words "Harden to R_C-40" have been added.

- Drawing 2006 has been eliminated.

- Drawing 2007

  The draft angles of the front and rear of the pump body now angle outwards instead of inwards.

  The title has been changed from "Pump Body; Bolt on Cap Type" to "Pump Body".

- Drawing 2008

  The nipples for holding the cotter pins in one position have been eliminated.

  The diameter of the holes through the handle have been increased from 41/64" to 29/32".

- Drawing 2009 has been eliminated.

- Drawing 2011 has been eliminated.

- Drawing 2012 has been eliminated.

- Drawing 2013

  The distance between pin holes has been increased from 4 3/4 plus 1/16 minus 0 to 4 13/16 plus 1/16 minus 0.

  In the Material & Treatment box, the words "Harden to R_C-40" have been added.

- Drawing 2014

  The note has been changed to state the following:

  "Cylinder may be made of either of the following materials:

  - For deep-well pump; STD P.V.C. 1120 plastic pipe (Sch 40)
  - For deep- or shallow-well pumps; P.V.C. pipe to be used as a liner inside a 3" galvanized steel pipe."

- Drawing 2017

  An asterisk along with the words "This size is for a 3" ID cylinder and will vary with the ID of the PVC-lined cylinder" has been added.

- Drawing 2019

  The diameter of the leather cup has been reduced from 3" Dia to 2 15/16" Dia.

  The title has been changed to "Leather Cup".

- Drawing 2020 has been eliminated.

- Drawing 2023

  The 8 holes on the pump base are now equally spaced on a 9 1/2" Dia B.C. instead of a 9" Dia B.C.

- Drawing 2026

  The nipples for holding the cotter pins in one position have been eliminated.

  The diameter of the hole has been increased from 41/64" to 29/32".

- Drawing 2027

  The location where the fulcrum handle connects to the pump cap has been raised.

  The hole diameter of this connecting section has been increased from 41/64" to 29/32".

  The nipples for holding the cotter pins in one position have been eliminated.

  The draft angle of the front of the pump cap (top view) has been changed so as to angle outwards instead of inwards.

  The title has been changed from "Pump Cap; Deep Well Pump; Bolt on Type" to "Pump Cap".

- Drawing 2028 has been eliminated.

- Drawing 2029

  The nipples for holding the cotter pins in one position have been eliminated.

  The length of the fulcrum handle (center to center) has been reduced from 8 3/8" to 8 1/4".

  The drilled holes have been increased from 41/64" to 29/32".

  The title has been changed from "Handle Fulcrum; Deep Well Pump" to "Handle Fulcrum".

- Drawing 2030

  The title has been changed from "Three Inch Plunger Assembly; Double Cup" to "Plunger Assembly; Double Cup".

- Drawing 2031

  An asterisk along with the words, "This size is for a 3" ID cylinder and will vary with the ID of the PVC pipe or liner" has been added.

- Drawing 2032

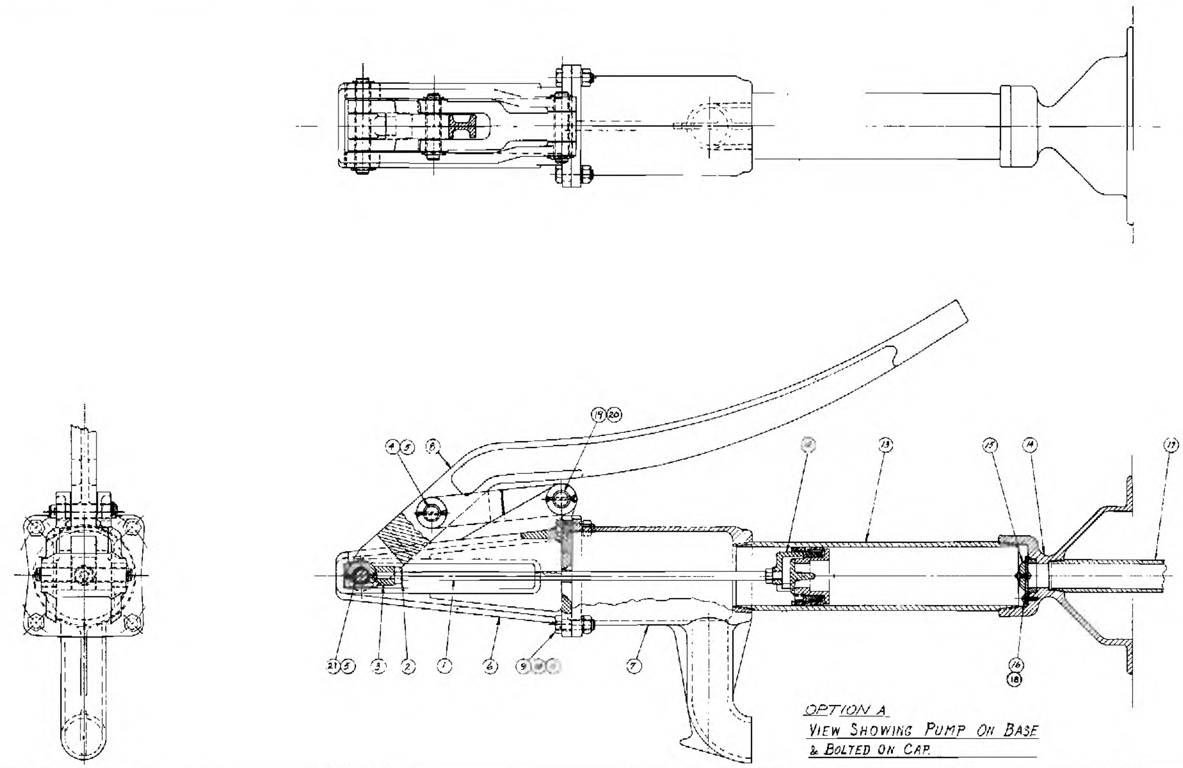
  An asterisk along with the words, "This size is for a 3" ID cylinder and will vary with the ID of the PVC pipe or liner" has been added.

- Drawing 2033 has been added.

- Drawing 2034 has been added.

REVISIONS

ZONE	LTR.	DESCRIPTION	DATE	APPROVED



OPTION A

VIEW SHOWING PUMP ON BASE & BOLTED ON CAP.

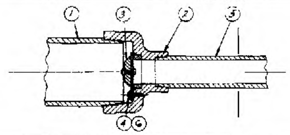
FIND NO.	QTY	PART NO. OR IDENTIFYING NO.	DWG. SIZE	DESCRIPTION	SPECIFICATION	NOTE NO.
21	1	2013	A	PIVOT PIN	5/8 x 5 1/4 CRS Rc40	
20	3	2034		BUSHING	STEEL – Rc 40	
19	8	2033		BUSHING	STEEL – Rc 40	
18	2	–	–	#10 PLAIN FLAT WASHER	BRASS	
17	A.R.	–	–	1 1/4 PIPE	ADD AT INSTALLATION	
16	2	–	–	MACHINE SCREW-RD. HD. BRASS	#10-24 x 1/2 NC-2A	
15	1	2015	B	CHECK VALVE ASSEM.		
14	1	2010	D	PUMP STAND ASSEM.		
13	1	2014	C	PUMP CYLINDER	3" SCHEDULE 40 PIPE (COATED)	
12	1	2009	B	PLUNGER ASSEM.-SINGLE CUP.		
11	4	–	–	LOCK WASHER	1/2 S.A.E. HEAVY	
10	4	–	–	NUT (HEX)	1/2-13 U.N.C.	
9	4	–	–	BOLT-HEX HD.	1/2-13 x 1 1/2	
8	1	2008	E	HANDLE	CAST IRON	
7	1	2007	D	PUMP BODY	CAST IRON	
6	1	2006	D	PUMP CAP	CAST IRON	
5	4	–	–	COTTER PIN (EXTENDED MITER)	1/8 x 1 1/2	
4	2	2005	A	PIVOT PIN	5/8 x 5 3/16 CRS Rc40	
3	1	2004	B	ROD END	CAST IRON	
2	2		–	PUMP ROD NUT (HEX)	7/16-14 U.N.C.	
1	1	2003	A	PLUNGER ROD	7/16 STP x 21 1/2	

PARTS LIST

NOTE:
ASSEMBLY OF PUMP BODY, PIPE & PUMP STAND MUST BE TIGHT WITH AT LEAST 15/16" THREAD ENGAGEMENT AT EACH JOINT.

OPTION B

VIEW SHOWING LOWER VALVE HOUSING MOUNT DIRECTLY TO WELL PIPE.



NOTE:
ALL PARTS ABOVE PUMP CYLINDER ARE IDENTICAL TO THOSE SHOWN IN VIEW OF PUMP SHOWN ABOVE OR BELOW.

FIND NO.	QTY.	PART NO. OR IDENTIFYING NO.	DWG. SIZE	DESCRIPTION	SPECIFICATION	NOTE NO.
6	2	–	–	#10 PLAIN FLAT WASHER	BRASS	
5	A.R.	–	–	1 1/4 PIPE	ADD AT INSTALLATION	
4	2	–	–	MACHINE SCREW-RD. HD. BRASS	#10-24 x 1/2 NC-2A	
3	1	2015	B	CHECK VALVE ASSEM.		
2	1	2016	C	LOWER VALVE HOUSING ASSEM.		
1	1	2014	–	PUMP CYLINDER	3" SCHEDULE 40 PIPE (COATED)	

PARTS LIST

FIND NO.	QTY.	PART NO. OR IDENTIFYING NO.	DWG. SIZE	DESCRIPTION	SPECIFICATION	NOTE NO.

PARTS LIST

APPLICATION — THIS ITEM IS USED ON

DO NOT SCALE DRAWING

Battelle Columbus Laboratories

TITLE: HAND PUMP ASSEMBLY SHALLOW WELL TYPE

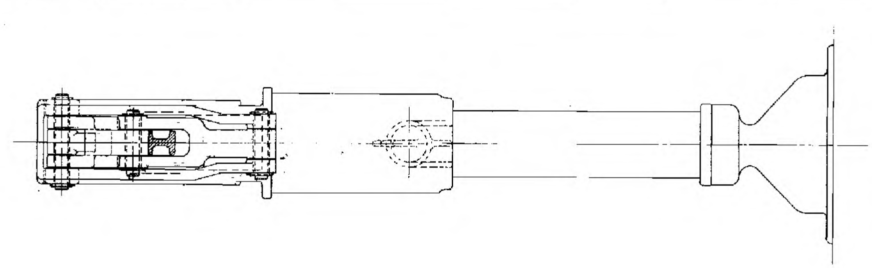
SIZE	CODE IDENT. NO.	DIV. NO.	DWG. NO.
E	79986	644	2001

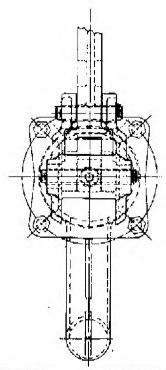
SCALE 1:2 ACCT. G1320-1 SHEET 1 OF 1

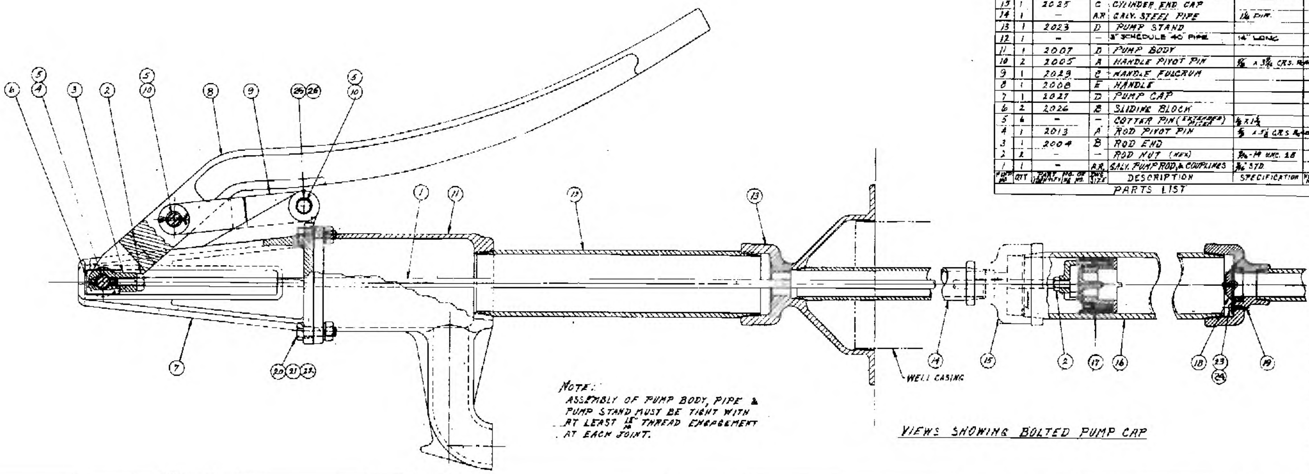
DWG. NO. 2001

26	3	2034		BUSHING	STEEL Rc 60-65	
25	8	2033		BUSHING	STEEL Rc 60-65	
24	1	–	–	#10 PLAIN FLAT WASHER	BRASS	
23	2	–	–	MACHINE SCREW - RD. HD. BRASS	10-24 x ½ NC-2A	
22	4	–	–	LOCK WASHER	½" SAE HEAVY	
21	4	–	–	NUT (HEX)	½-13 UNC.	
20	4	–	–	BOLT - HEX HD.	½-13 X 1¼	
19	1	2016	C	LOWER VALVE HOUSING		
18	1	2015	B	CHECK VALVE ASSY.		
17	1	2030	C	PLUNGER ASSEM.		
16	1	2014	C	PUMP CYLINDER	3" SCHEDULE 40 PIPE (PVC OR COATED)	
15	1	2025	C	CYLINDER END CAP		
14	1	–	A.R.	GALV. STEEL PIPE	1¼ DIA.	
13	1	2023	D	PUMP STAND		
12	1	–	–	3" SCHEDULE 40 PIPE	14" LONG	
11	1	2007	D	PUMP BODY		
10	2	2005	A	HANDLE PIVOT PIN	⅝ x 3⁹⁄₁₆ CRS. ROD	
9	1	2029	C	HANDLE FULCRUM		
8	1	2008	E	HANDLE		
7	1	2027	D	PUMP CAP		
6	2	2026	B	SLIDING BLOCK		
5	6	–	–	COTTER PIN (EXTENDED MITER)	⅛ x 1½	
4	1	2013	A	ROD PIVOT PIN	⅝ x 5⅛ CRS ROD	
3	1	2004	B	ROD END		
2	2	–	–	ROD NUT (HEX)	⁷⁄₁₆-14 UNC. 2B	
1	1	–	A.R.	GALV. PUMP ROD, & COUPLINGS	⁷⁄₁₆" STD.	
FIND NO.	QTY	PART NO. OR IDENTIFYING NO.	DWG. SIZE	DESCRIPTION	SPECIFICATION	NOTE NO.

PARTS LIST







NOTE:
ASSEMBLY OF PUMP BODY, PIPE & PUMP STAND MUST BE TIGHT WITH AT LEAST 1/2" THREAD ENGAGEMENT AT EACH JOINT.

VIEWS SHOWING BOLTED PUMP CAP

FIND NO.	QTY.	PART NO. OR IDENTIFYING NO.	DWG. SIZE	DESCRIPTION	SPECIFICATION	NOTE NO.

PARTS LIST

APPLICATION

DO NOT SCALE DRAWING

SIGNATURE	DIV.	DATE
[illegible]	606	9/18/74

Battelle Columbus Laboratories

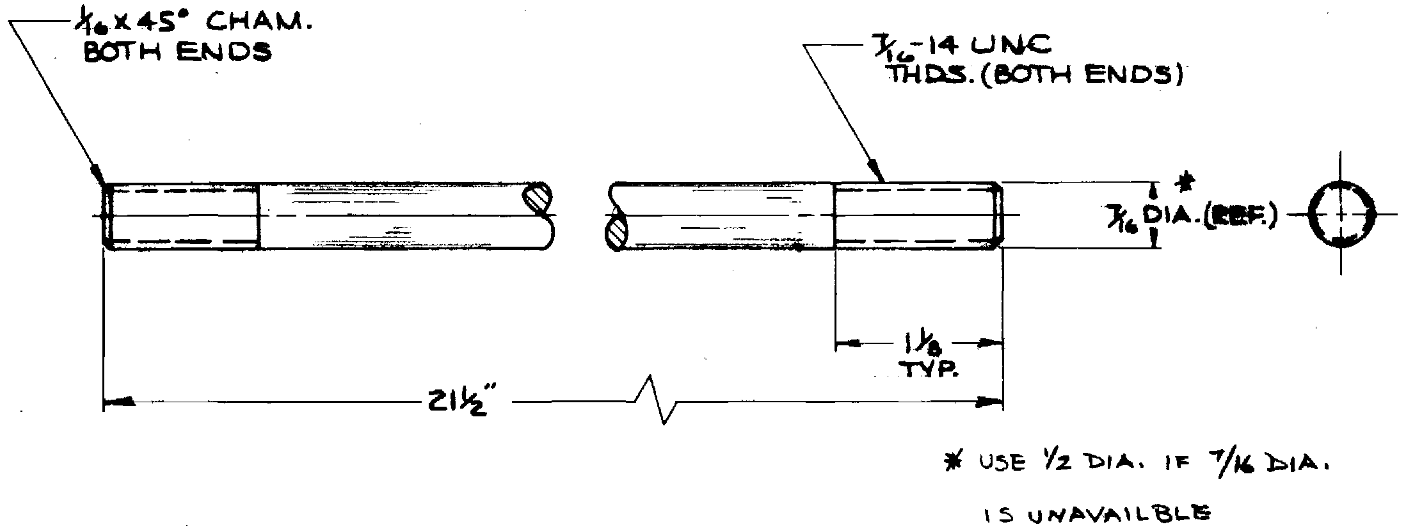
TITLE
HAND PUMP ASSEMBLY
DEEP WELL TYPE

SIZE	CODE IDENT. NO.	DIV. NO.	DWG. NO.	REV
E	79986	606	2002	

SCALE 1=2 | ASSY G 1320-1 | SHEET 1 OF 1

2002

REVISIONS			
LTR	DESCRIPTION	DATE	APPROVED



APPLICATION			
THIS ITEM IS USED ON SUBASSEMBLIES			
DRAWING NO.	PER ASSY	NO. OF ASSYS	TOTAL
2001	1	1	1
TO MAKE FINAL ASSEMBLY			TOTAL REQ'D.

DO NOT SCALE DRAWING

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES. TOLERANCES ARE: ± 1/32
.XX = – .XXXX = –
.XXX = – ANGLES = ± 1/2°

MATERIAL & TREATMENT
7/16 DIA. GALV.
PUMP ROD

SIGNATURE	DIV.	DATE
DRAWN BY	6??	1-7-7?
DRAFTING APPD.		
DESIGN APPD.		
APPD.		
PROJECT APPD.		
SPECIAL APPD.		

BATTELLE MEMORIAL INSTITUTE
COLUMBUS LABORATORIES
505 KING AVE., COLUMBUS, OHIO 43201

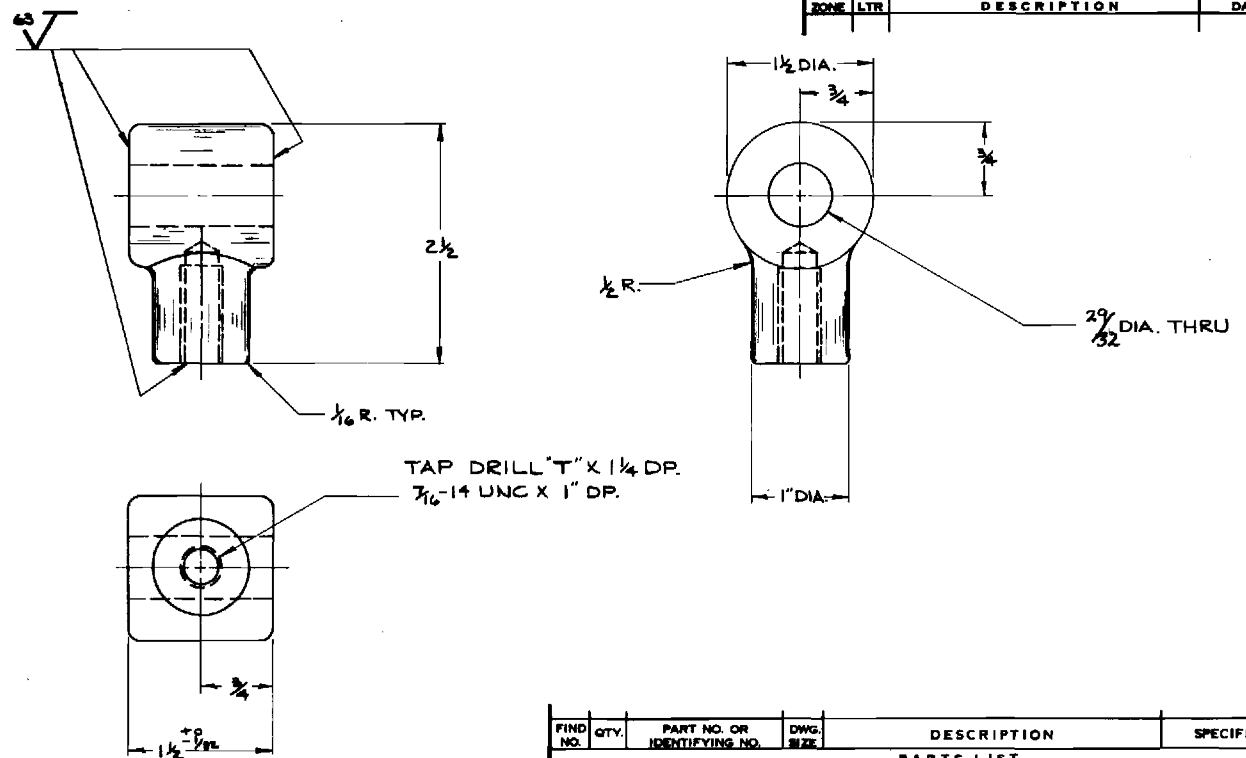
TITLE PLUNGER ROD

SIZE	CODE IDENT. NO.	DIV. NO.	DWG. NO.	REV.
A	79986	644	2003	

SCALE "=" ACCT. G1320-1 SHEET 1 OF 1

CAT. 204163 FORM D-6 5-70

REVISIONS				
ZONE	LTR	DESCRIPTION	DATE	APPROVED



NOTES:

1. ALL DRAFT ANGLES TO BE 1½° TO 4°
2. ALL FILLETS & RADII TO BE ⅛" R. UNLESS OTHERWISE SPECIFIED

FIND NO.	QTY.	PART NO. OR IDENTIFYING NO.	DWG. SIZE	DESCRIPTION	SPECIFICATION	NOTE NO.

PARTS LIST

APPLICATION			
THIS ITEM IS USED ON ASSEMBLIES			
DRAWING NO.	PER ASSY	NO. OF ASSYS	TOTAL
2001	1	1	1
2002	1	1	1
TO MAKE FINAL ASSEMBLY			TOTAL REQ'D.

DO NOT SCALE DRAWING

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES. TOLERANCES ARE: ± 1/32

.XX = – .XXXX = –
.XXX = – ANGLES = –

MATERIAL & TREATMENT: CAST IRON

SIGNATURE	DIV.	DATE
DRAWN BY	659	1-8-79
DRAFTING APPD.		
DESIGN APPD.		
APPD.		
PROJECT APPD.		
SPECIAL APPD.		

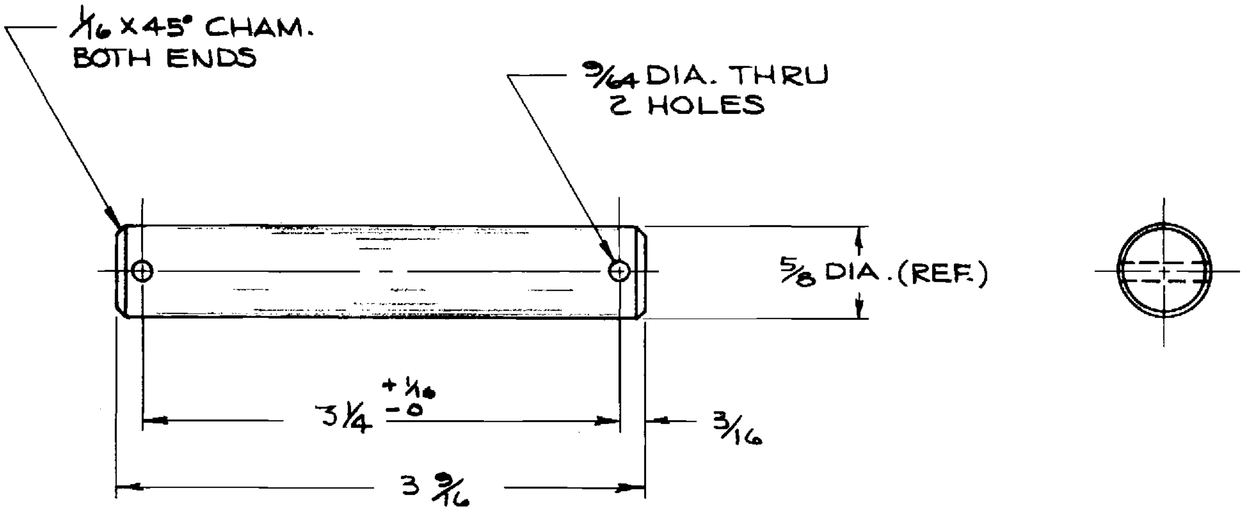
Battelle Columbus Laboratories
505 King Avenue
Columbus, Ohio 43201
Telephone (614) 299-3151

TITLE: ROD END

SIZE	CODE IDENT. NO.	DIV. NO.	DWG. NO.	REV.
B	79986	644	2004	
SCALE 1"=1"	ACCT. G1320-1		SHEET 1 OF 1	

CAT. 684165
FORM D-7 12-78

REVISIONS			
LTR	DESCRIPTION	DATE	APPROVED



APPLICATION			
THIS ITEM IS USED ON ASSEMBLIES			
DRAWING NO.	PER ASSY	NO. OF ASSYS	TOTAL
2002	2	1	2
2001 "A"	2	1	2
TO MAKE FINAL ASSEMBLY			TOTAL REQ'D.

DO NOT SCALE DRAWING

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES. TOLERANCES ARE: ± 1/32

.XX = — .XXXX = —

.XXX = — ANGLES = ± 1/2°

MATERIAL & TREATMENT

5/8 DIA. C.R.S. ROUND

HARDEN TO Rc 40

SIGNATURE	DIV.	DATE
DRAWN BY	659	1-7-74
DRAFTING APPD.		
DESIGN APPD.		
APPD.		
PROJECT APPD.		
SPECIAL APPD.		

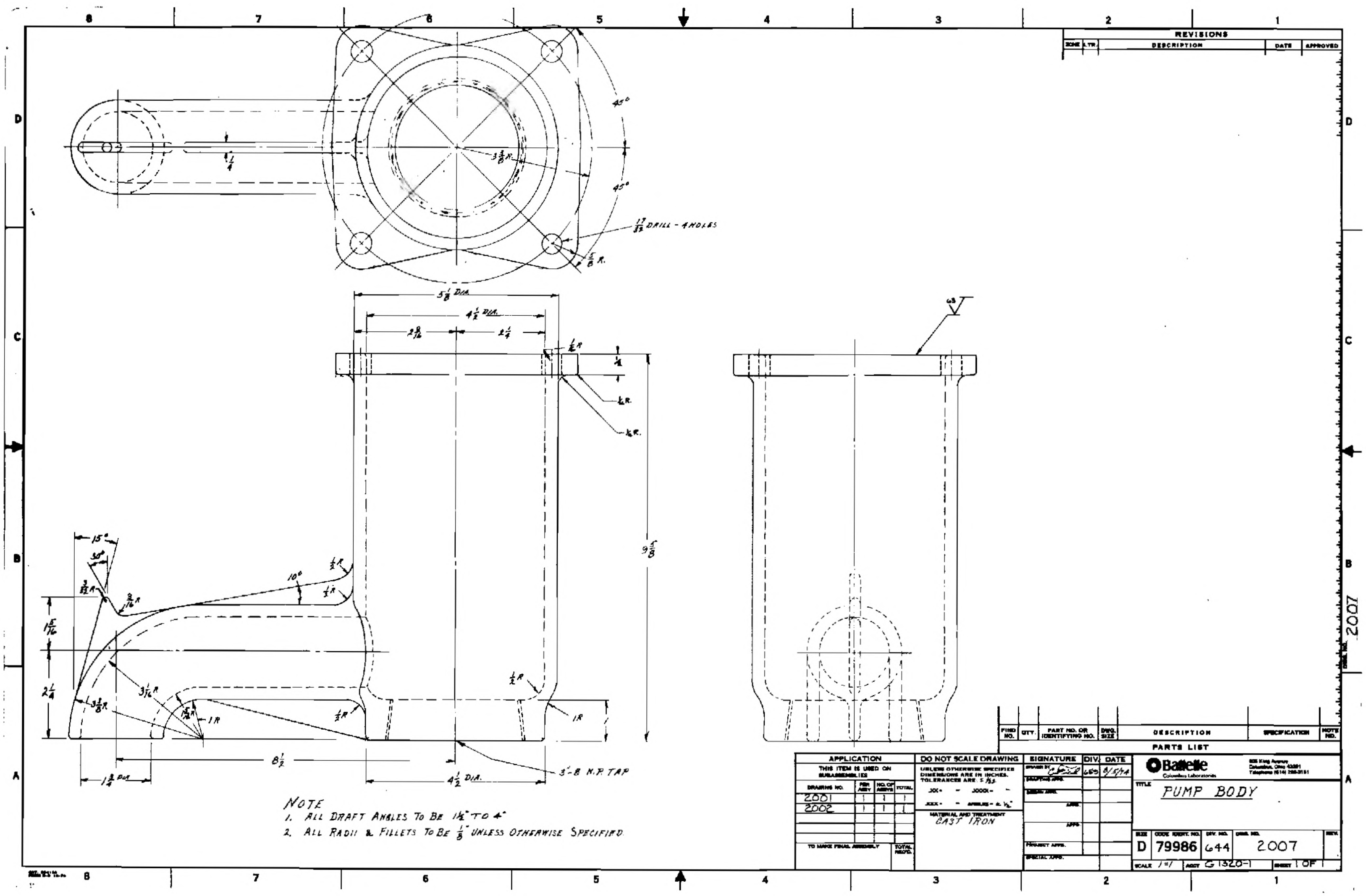
BATTELLE MEMORIAL INSTITUTE
COLUMBUS LABORATORIES
505 KING AVE., COLUMBUS, OHIO 43201

TITLE: HANDLE PIVOT PIN

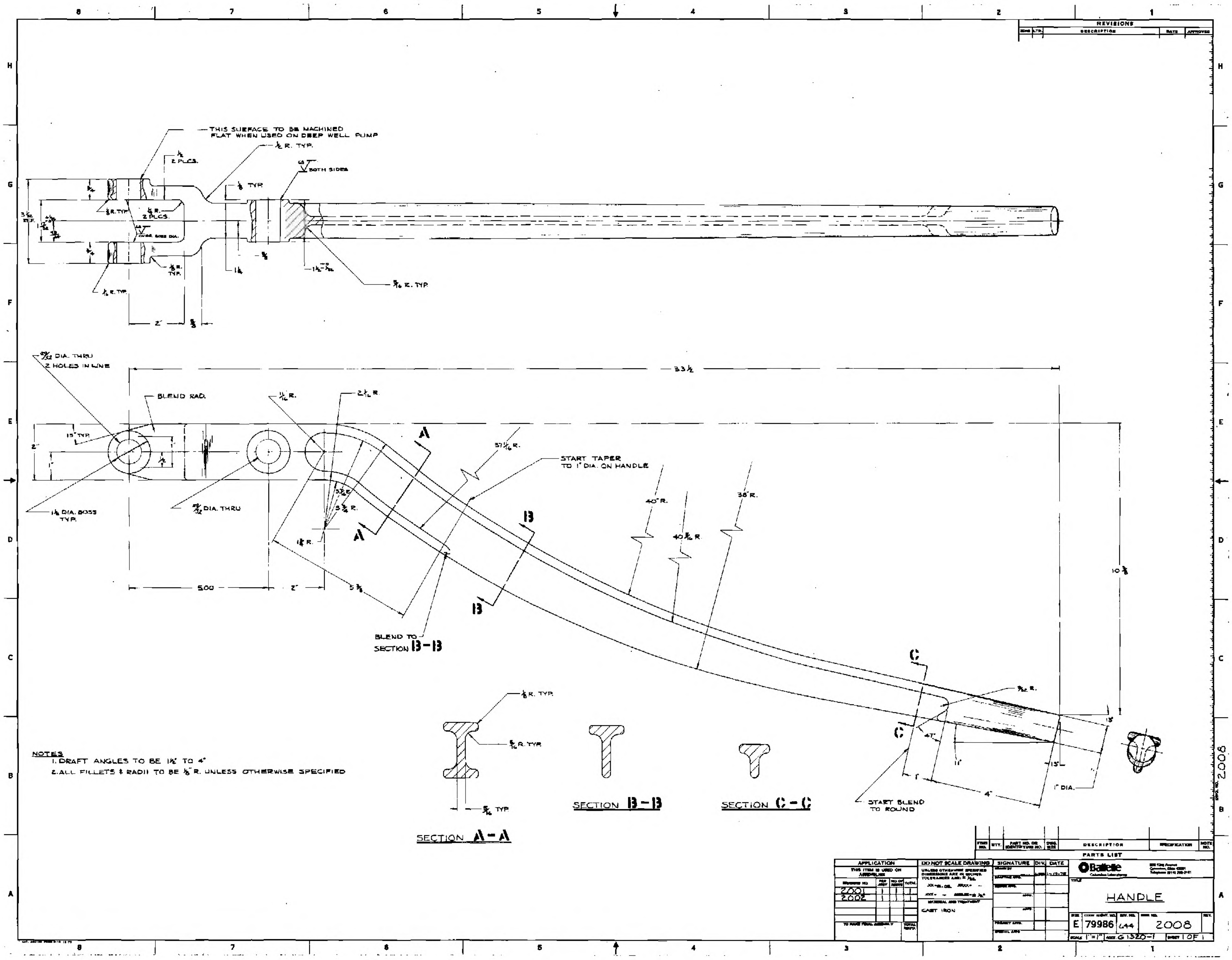
SIZE	CODE IDENT. NO.	DIV. NO.	DWG. NO.	REV.
A	79986	644	2005	

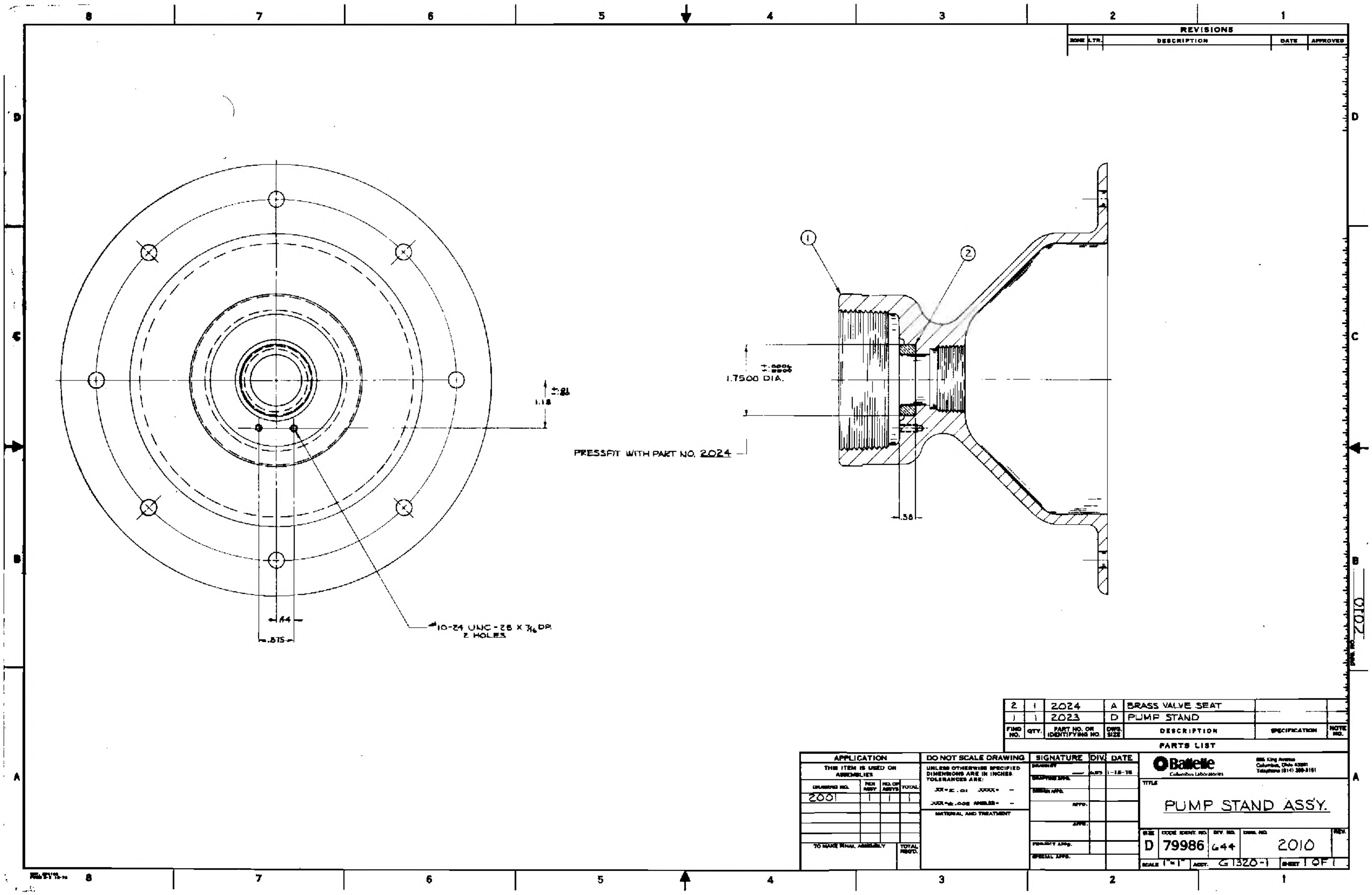
SCALE 1" = 1" ACCT. G1320-1 SHEET 1 OF 1

CAT. 894163 FORM D-5 5-70



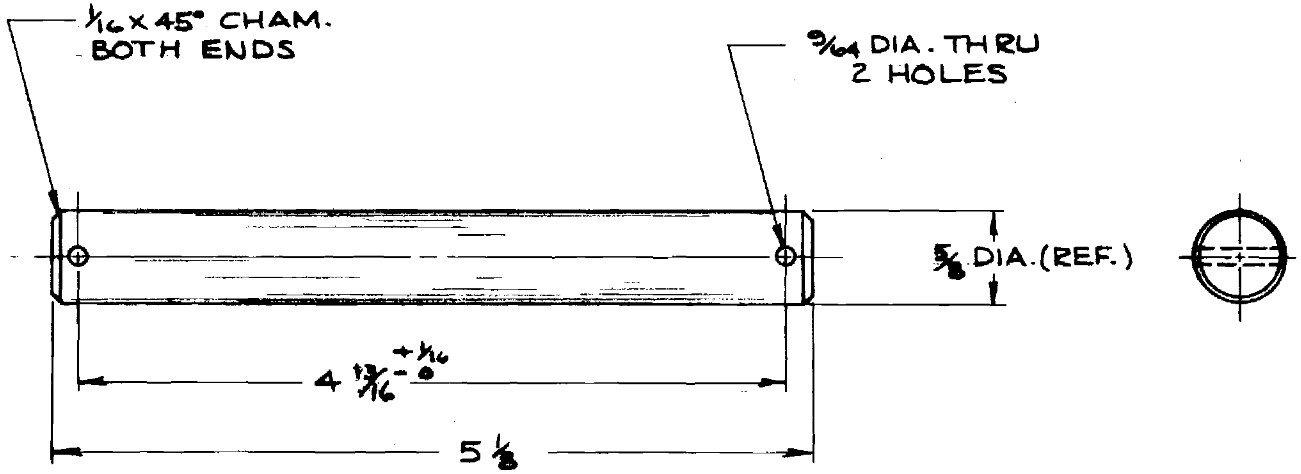
REVISIONS
ZONE LTR. DESCRIPTION DATE APPROVED
$\frac{17}{32}$ DRILL - 4 HOLES
$5\frac{1}{8}$ DIA.
$4\frac{1}{2}$ DIA.
$9\frac{5}{8}$
$8\frac{1}{2}$
$1\frac{3}{4}$ DIA.
$\frac{3}{4}$" - 8 N.P. TAP
NOTE
1. ALL DRAFT ANGLES TO BE $1\frac{1}{2}$° TO 4°
2. ALL RADII & FILLETS TO BE $\frac{1}{8}$" UNLESS OTHERWISE SPECIFIED
FIND NO. QTY. PART NO. OR IDENTIFYING NO. DWG. SIZE DESCRIPTION SPECIFICATION NOTE NO.
PARTS LIST
APPLICATION
THIS ITEM IS USED ON SUBASSEMBLIES
DRAWING NO. PER ASSY NO. OF ASSYS TOTAL
2001 1 1 1
2002 1 1 1
TO MAKE FINAL ASSEMBLY TOTAL REQ'D.
DO NOT SCALE DRAWING
UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES. TOLERANCES ARE: ± $\frac{1}{32}$
MATERIAL AND TREATMENT
CAST IRON
SIGNATURE DIV. DATE
665 8/5/74
DRAFTING APPR.
PROJECT APPR.
SPECIAL APPR.
Battelle
Columbus Laboratories
TITLE PUMP BODY
SIZE D CODE IDENT. NO. 79986 DIV. NO. 644 DWG. NO. 2007
SCALE 1=1 ACCT G1320-1 SHEET 1 OF 1


THIS SURFACE TO BE MACHINED FLAT WHEN USED ON DEEP WELL PUMP
BOTH SIDES
BLEND RAD.
START TAPER TO 1" DIA. ON HANDLE
2 HOLES IN LINE
33 1/2
BLEND TO SECTION B-B
START BLEND TO ROUND
NOTES
1. DRAFT ANGLES TO BE 1 1/2° TO 4°
2. ALL FILLETS & RADII TO BE 1/8" R. UNLESS OTHERWISE SPECIFIED
SECTION A-A
SECTION B-B
SECTION C-C
REVISIONS
PARTS LIST
APPLICATION
DO NOT SCALE DRAWING
CAST IRON
Battelle
Columbus Laboratories
HANDLE
E 79986
2008
G 1320-1



REVISIONS
ZONE
LTR.
DESCRIPTION
DATE
APPROVED
1.7500 DIA.
PRESSFIT WITH PART NO. 2024
10-24 UNC-2B X 7/16 DP.
2 HOLES
.64
.875
1.18
.38
2 | 1 | 2024 | A | BRASS VALVE SEAT
1 | 1 | 2023 | D | PUMP STAND
FIND NO. | QTY. | PART NO. OR IDENTIFYING NO. | DWG. SIZE | DESCRIPTION | SPECIFICATION | NOTE NO.
PARTS LIST
APPLICATION
THIS ITEM IS USED ON ASSEMBLIES
2001
TO MAKE FINAL ASSEMBLY
TOTAL REQ'D.
DO NOT SCALE DRAWING
UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES. TOLERANCES ARE:
SIGNATURE
DIV.
DATE
1-15-75
Battelle
Columbus Laboratories
TITLE
PUMP STAND ASSY.
D
79986
644
2010
SCALE 1"=1"
ACCT. G1320-1
SHEET 1 OF 1

REVISIONS			
LTR	DESCRIPTION	DATE	APPROVED



APPLICATION			
THIS ITEM IS USED ON SUBASSEMBLIES			
DRAWING NO.	PER ASSY	NO. OF ASSYS	TOTAL
2001 "A"	1	1	1
2002	1	1	1
TO MAKE FINAL ASSEMBLY			TOTAL REQ'D.

DO NOT SCALE DRAWING

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES. TOLERANCES ARE: ± 1/32

.XX = .XXXX = —

.XXX = — ANGLES = ± 1/2°

MATERIAL & TREATMENT

5/8 C.R.S. ROUND

HARDEN TO R_c 40

SIGNATURE	DIV.	DATE
DRAWN BY	659	1-7-75
DRAFTING APPD.		
DESIGN APPD.		
APPD.		
PROJECT APPD.		
SPECIAL APPD.		

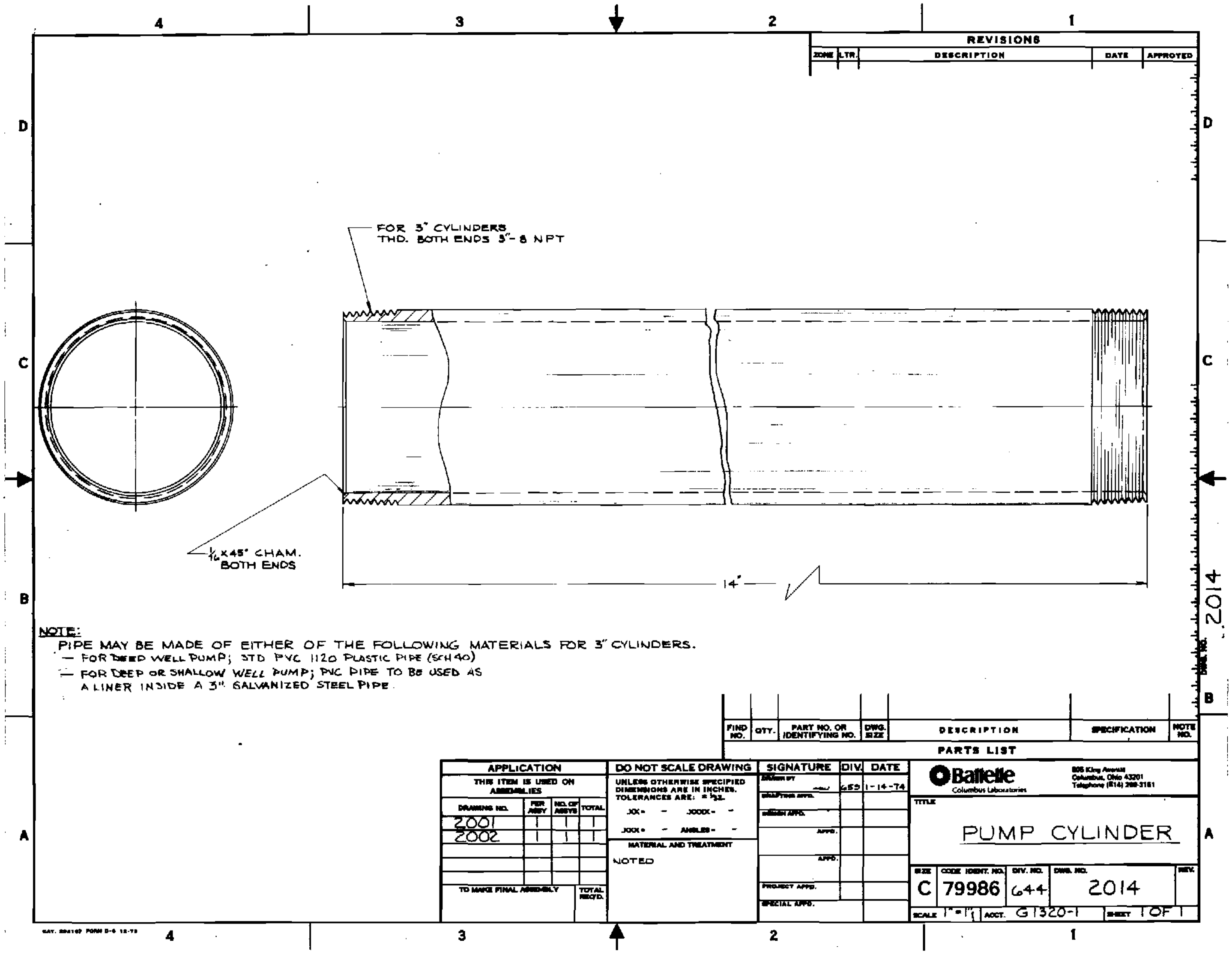
BATTELLE MEMORIAL INSTITUTE
COLUMBUS LABORATORIES
505 KING AVE., COLUMBUS, OHIO 43201

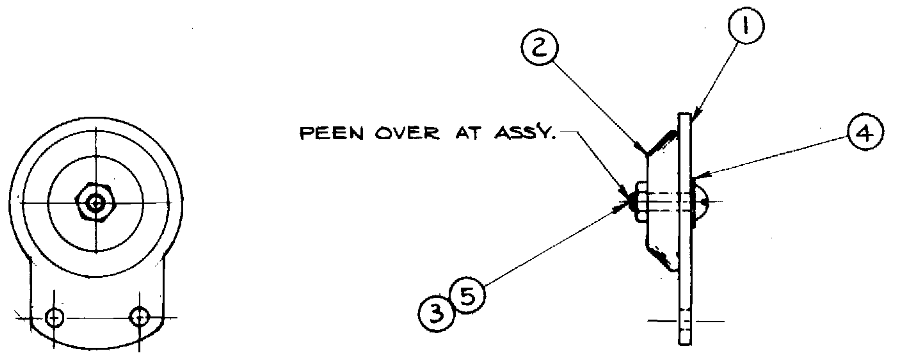
TITLE: ROD PIVOT PIN

SIZE	CODE IDENT. NO.	DIV. NO.	DWG. NO.	REV.
A	79986	644	2013	

SCALE 1" = 1" ACCT. G 1320-1 SHEET 1 OF 1

CAT. 204183 FORM D-5 5-70


REVISIONS
ZONE LTR. DESCRIPTION DATE APPROVED
FOR 3" CYLINDERS
THD. BOTH ENDS 3"-8 NPT
1/16 X45° CHAM.
BOTH ENDS
14"
NOTE:
PIPE MAY BE MADE OF EITHER OF THE FOLLOWING MATERIALS FOR 3" CYLINDERS.
— FOR DEEP WELL PUMP; STD PVC 1120 PLASTIC PIPE (SCH 40)
— FOR DEEP OR SHALLOW WELL PUMP; PVC PIPE TO BE USED AS
A LINER INSIDE A 3" GALVANIZED STEEL PIPE.
FIND NO. QTY. PART NO. OR IDENTIFYING NO. DWG. SIZE DESCRIPTION SPECIFICATION NOTE NO.
PARTS LIST
APPLICATION
THIS ITEM IS USED ON ASSEMBLIES
DRAWING NO. PER ASSY NO. OF ASSYS TOTAL
2001 1 1 1
2002 1 1 1
TO MAKE FINAL ASSEMBLY TOTAL REQ'D.
DO NOT SCALE DRAWING
UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES. TOLERANCES ARE: ± 1/32
MATERIAL AND TREATMENT
NOTED
SIGNATURE DIV. DATE
655 1-14-74
Battelle
Columbus Laboratories
505 King Avenue
Columbus, Ohio 43201
TITLE
PUMP CYLINDER
SIZE CODE IDENT. NO. DIV. NO. DWG. NO. REV.
C 79986 644 2014
SCALE 1"=1" ACCT. G1320-1 SHEET 1 OF 1
DWG. NO. 2014



5	1	–	–	#10 NC-2B HEX NUT	BRASS	
4	1	–	–	#10 PLAIN FLAT WASHER	BRASS	
3	1	–	–	#10-24 NC-2A X 3/4 LONG RD. HD. SCR.	BRASS	
2	1	2022	A	CHECK VALVE WEIGHT		
1	1	2021	B	VALVE FLAPPER		
FIND NO.	QTY.	PART NO. OR IDENTIFYING NO.	DWG. SIZE	DESCRIPTION	SPECIFICATION	NOTE NO.

PARTS LIST

APPLICATION

THIS ITEM IS USED ON ASSEMBLIES

DRAWING NO.	PER ASSY	NO. OF ASSYS	TOTAL
2001	1	1	1
2002	1	1	1

TO MAKE FINAL ASSEMBLY — TOTAL REQ'D.

DO NOT SCALE DRAWING

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES. TOLERANCES ARE:
.XX = .XXXX =
.XXX = ANGLES =

MATERIAL & TREATMENT

SIGNATURE	DIV.	DATE
DRAWN BY	659	1-9-75
DRAFTING APPD.		
DESIGN APPD.		
APPD.		
PROJECT APPD.		
SPECIAL APPD.		

Battelle Columbus Laboratories
505 King Avenue
Columbus, Ohio 43201
Telephone (614) 299-3151

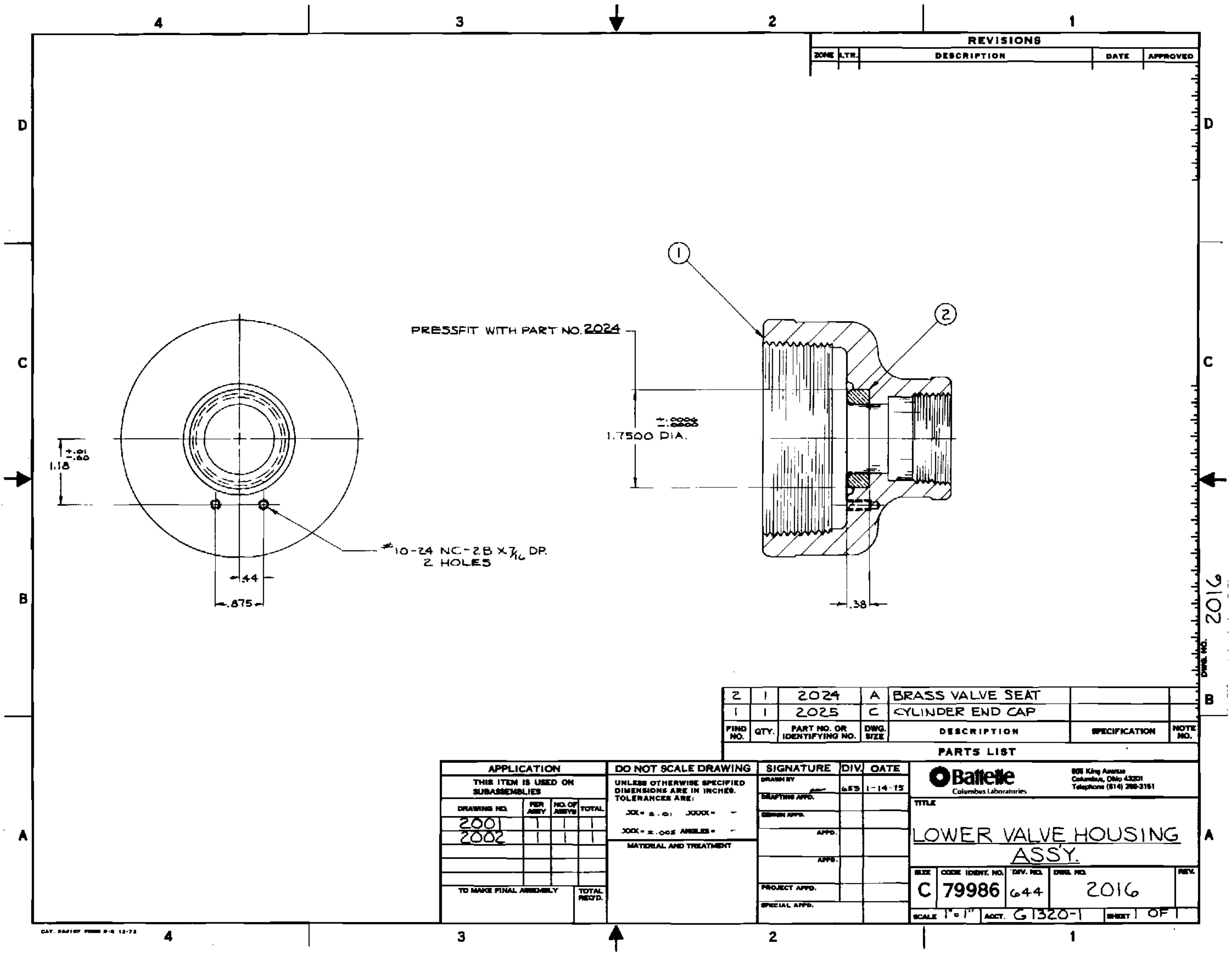
TITLE

CHECK VALVE ASSY.

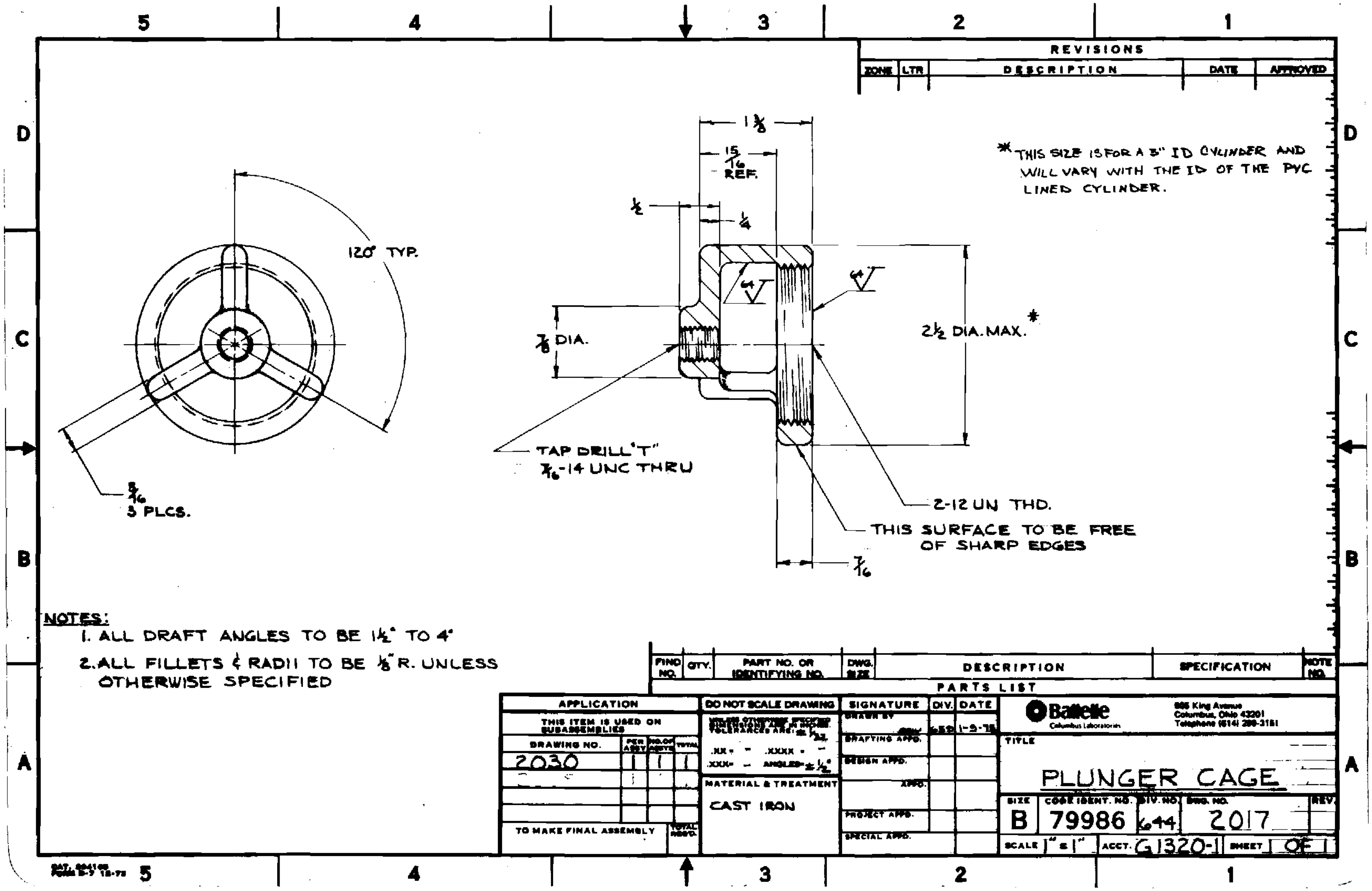
SIZE	CODE IDENT. NO.	DIV. NO.	DWG. NO.	REV.
B	79986	644	2015	

SCALE 1" = 1" ACCT. SHEET OF

CAT. 824165 FORM B-7 12-73



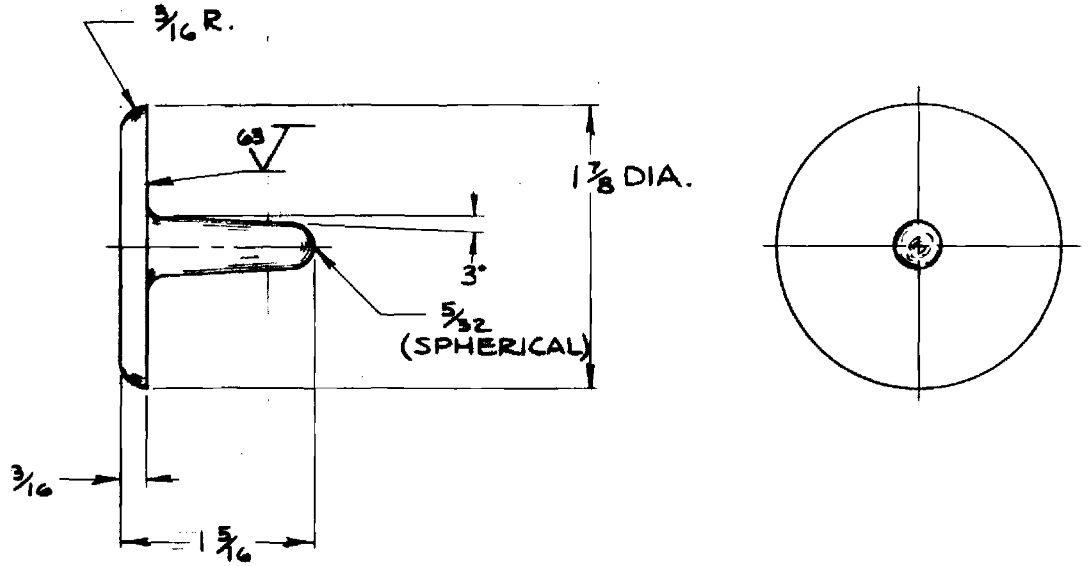
FIND NO.	QTY.	PART NO. OR IDENTIFYING NO.	DWG. SIZE	DESCRIPTION	SPECIFICATION	NOTE NO.
2	1	2024	A	BRASS VALVE SEAT		
1	1	2025	C	CYLINDER END CAP		


REVISIONS
ZONE
LTR
DESCRIPTION
DATE
APPROVED
*THIS SIZE IS FOR A 3" ID CYLINDER AND WILL VARY WITH THE ID OF THE PVC LINED CYLINDER.
1 3/8
15/16 REF.
1/2
1/4
120° TYP.
7/8 DIA.
2 1/2 DIA. MAX.*
TAP DRILL "T" 7/16-14 UNC THRU
5/16 3 PLCS.
2-12 UN THD.
THIS SURFACE TO BE FREE OF SHARP EDGES
7/16
NOTES:
1. ALL DRAFT ANGLES TO BE 1 1/2° TO 4°
2. ALL FILLETS & RADII TO BE 1/8" R. UNLESS OTHERWISE SPECIFIED
FIND NO.
QTY.
PART NO. OR IDENTIFYING NO.
DWG. SIZE
DESCRIPTION
SPECIFICATION
NOTE NO.
PARTS LIST
APPLICATION
THIS ITEM IS USED ON SUBASSEMBLIES
DRAWING NO.
2030
TO MAKE FINAL ASSEMBLY
DO NOT SCALE DRAWING
MATERIAL & TREATMENT
CAST IRON
SIGNATURE
DIV.
DATE
DRAWN BY
DRAFTING APPD.
DESIGN APPD.
PROJECT APPD.
SPECIAL APPD.
Battelle
Columbus Laboratories
505 King Avenue
Columbus, Ohio 43201
TITLE
PLUNGER CAGE
SIZE
B
CODE IDENT. NO.
79986
DIV. NO.
644
DWG. NO.
2017
REV.
SCALE 1" = 1"
ACCT. G1320-1
SHEET 1 OF 1

NOTES:

1. ALL DRAFT ANGLES TO BE 1½° TO 4°
2. ALL FILLETS & RADII TO BE ⅛" R. UNLESS OTHERWISE SPECIFIED

REVISIONS			
LTR	DESCRIPTION	DATE	APPROVED



APPLICATION			
THIS ITEM IS USED ON SUBASSEMBLIES			
DRAWING NO.	PER ASSY	NO. OF ASSYS	TOTAL
2030	1	1	1
TO MAKE FINAL ASSEMBLY			TOTAL REQ'D.

DO NOT SCALE DRAWING

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES. TOLERANCES ARE: ± 1/32

.XX = – .XXXX = –

.XXX = – ANGLES = ± ½°

MATERIAL & TREATMENT: CAST IRON

SIGNATURE	DIV.	DATE
DRAWN BY [signature]	659	1-7-75
DRAFTING APPD.		
DESIGN APPD.		
APPD.		
PROJECT APPD.		
SPECIAL APPD.		

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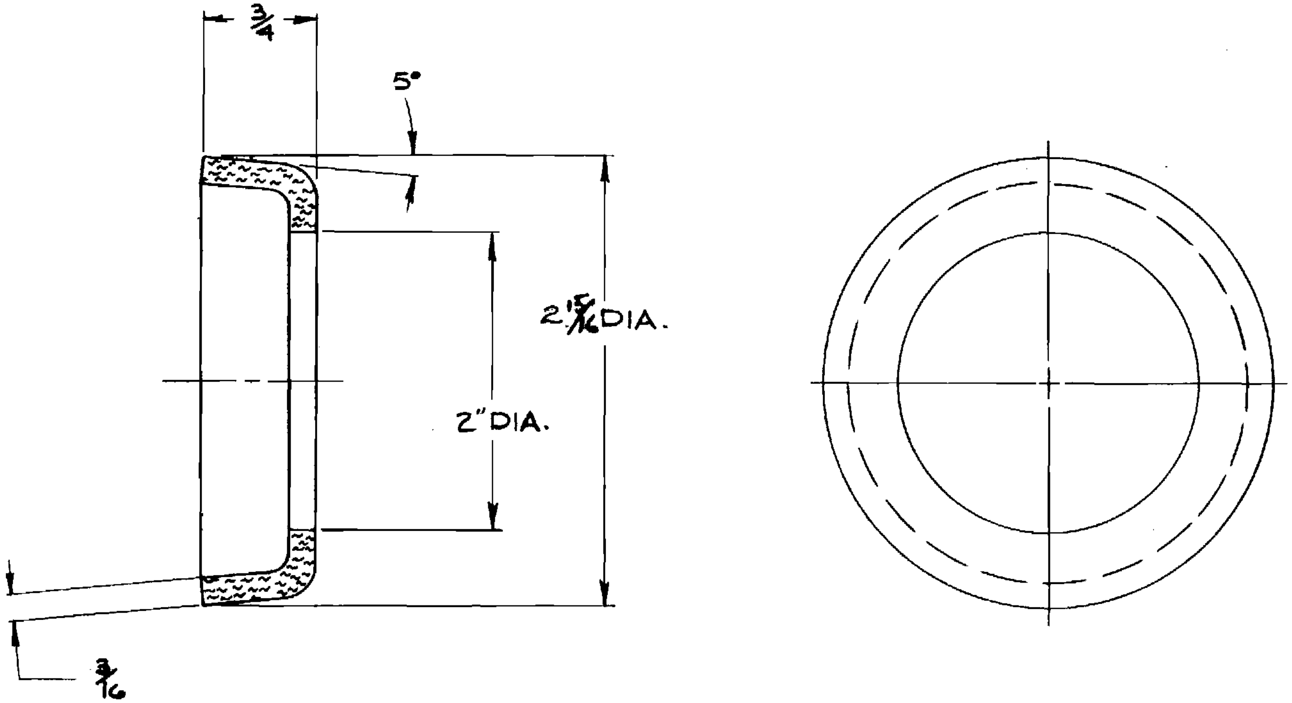
TITLE: PLUNGER POPPET

SIZE	CODE IDENT. NO.	DIV. NO.	DWG. NO.	REV.
A	79986	644	2018	

SCALE 1" = 1" ACCT. G1320-1 SHEET 1 OF 1

CAT. 204183 FORM D-5 5-70

REVISIONS			
LTR	DESCRIPTION	DATE	APPROVED



APPLICATION			
THIS ITEM IS USED ON SUBASSEMBLIES			
DRAWING NO.	PER ASSY	NO. OF ASSYS	TOTAL
2030	1	1	1
TO MAKE FINAL ASSEMBLY			TOTAL REQ'D.

DO NOT SCALE DRAWING

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES. TOLERANCES ARE: ± 1/32

.XX = — .XXXX = —

.XXX = — ANGLES = ± 1°

MATERIAL & TREATMENT: LEATHER

SIGNATURE	DIV.	DATE
DRAWN BY	659	1-7-75
DRAFTING APPD.		
DESIGN APPD.		
APPD.		
PROJECT APPD.		
SPECIAL APPD.		

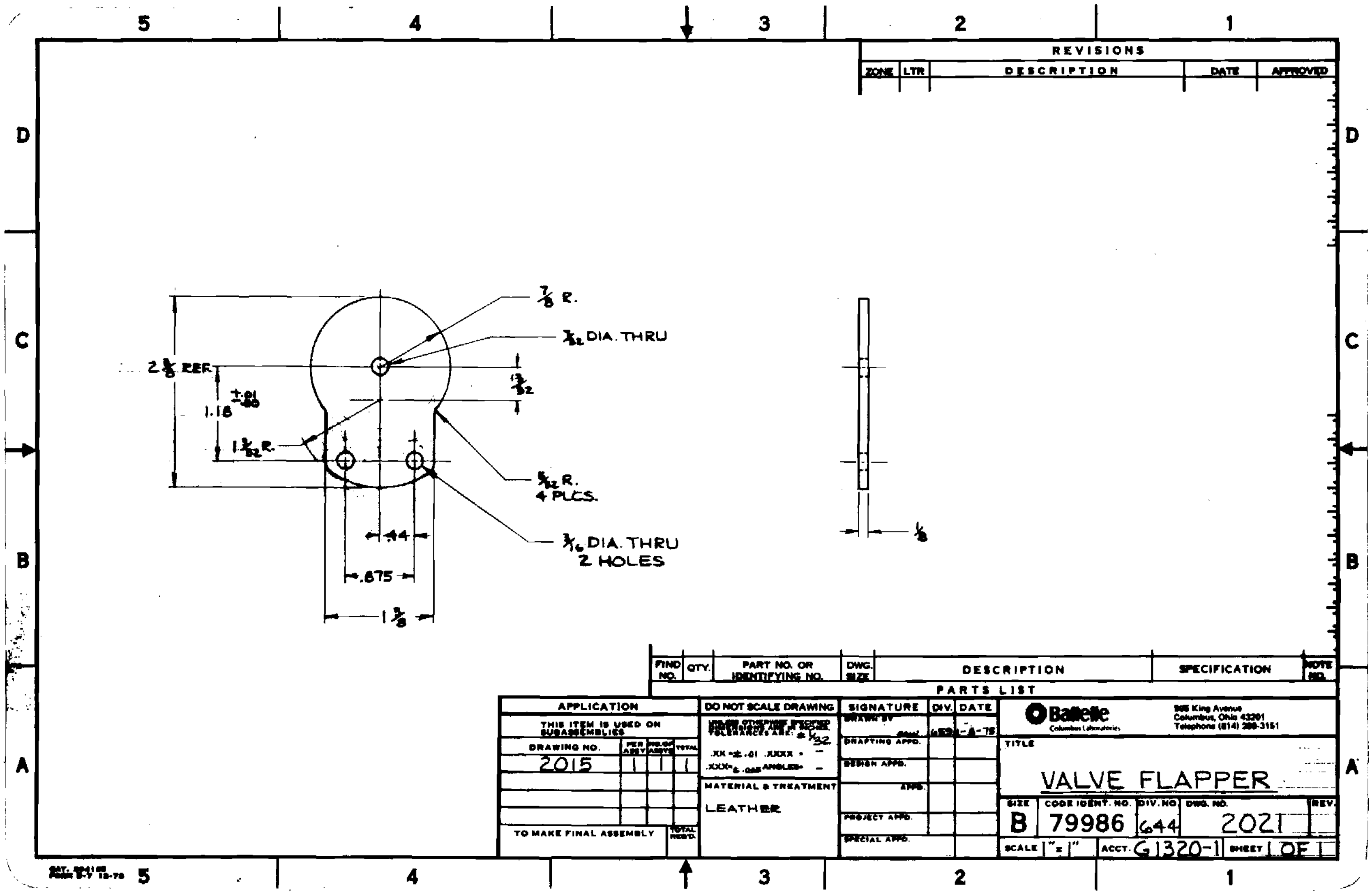
BATTELLE MEMORIAL INSTITUTE
COLUMBUS LABORATORIES
505 KING AVE., COLUMBUS, OHIO 43201

TITLE: LEATHER CUP

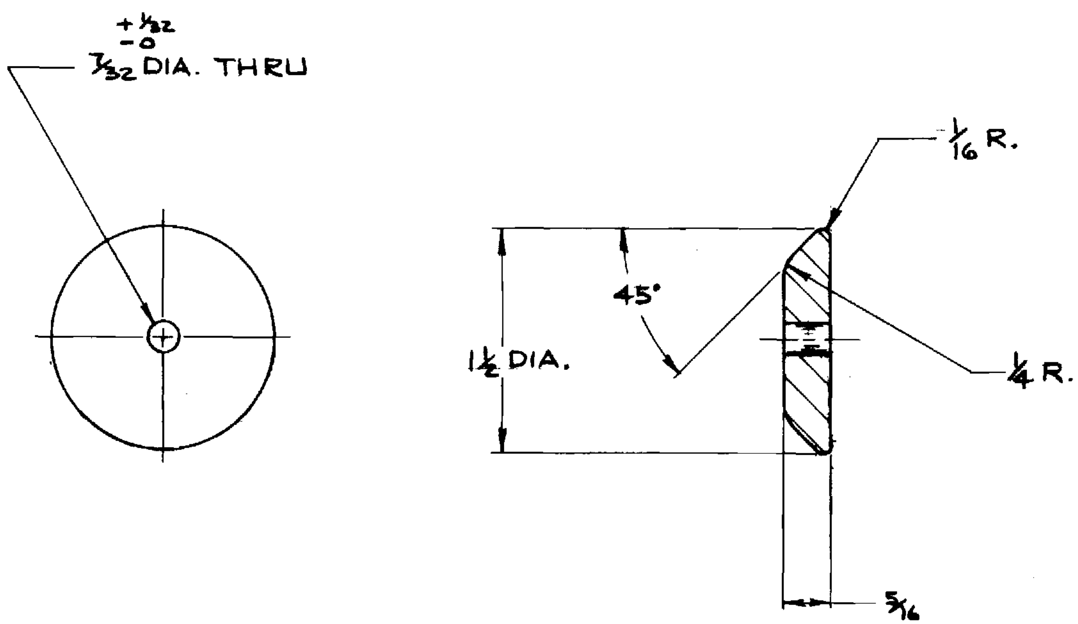
SIZE	CODE IDENT. NO.	DIV. NO.	DWG. NO.	REV.
A	79986	644	2019	

SCALE 1" = 1" ACCT. G1320-1 SHEET 1 OF 1

CAT. 294163 FORM D-3 5-70


7/8 R.
3/32 DIA. THRU
2 3/8 REF.
1.18 +.01 -.00
13/32
1 3/32 R.
5/32 R.
4 PLCS.
.44
.875
1 3/8
3/16 DIA. THRU
2 HOLES
1/8
REVISIONS
ZONE
LTR
DESCRIPTION
DATE
APPROVED
FIND NO.
QTY.
PART NO. OR IDENTIFYING NO.
DWG. SIZE
DESCRIPTION
SPECIFICATION
NOTE NO.
PARTS LIST
APPLICATION
THIS ITEM IS USED ON SUBASSEMBLIES
DRAWING NO.
2015
TO MAKE FINAL ASSEMBLY
DO NOT SCALE DRAWING
.XX = ±.01
MATERIAL & TREATMENT
LEATHER
SIGNATURE
DIV.
DATE
DRAFTING APPD.
DESIGN APPD.
PROJECT APPD.
SPECIAL APPD.
Battelle
Columbus Laboratories
505 King Avenue
Columbus, Ohio 43201
TITLE
VALVE FLAPPER
SIZE
B
CODE IDENT. NO.
79986
DIV. NO.
644
DWG. NO.
2021
REV.
SCALE
1" = 1"
ACCT.
G1320-1
SHEET
1 OF 1

REVISIONS			
LTR	DESCRIPTION	DATE	APPROVED



APPLICATION			
THIS ITEM IS USED ON SUBASSEMBLIES			
DRAWING NO.	PER ASSY	NO. OF ASSYS	TOTAL
2015	1	1	1
TO MAKE FINAL ASSEMBLY			TOTAL REQ'D

DO NOT SCALE DRAWING

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES. TOLERANCES ARE: 1/32

.XX = – .XXXX = –

.XXX = – ANGLES = ± 1/2°

MATERIAL & TREATMENT

CAST IRON

SIGNATURE	DIV.	DATE
DRAWN BY	659	1-8-75
DRAFTING APPD.		
DESIGN APPD.		
APPD.		
PROJECT APPD.		
SPECIAL APPD.		

BATTELLE MEMORIAL INSTITUTE
COLUMBUS LABORATORIES
505 KING AVE., COLUMBUS, OHIO 43201

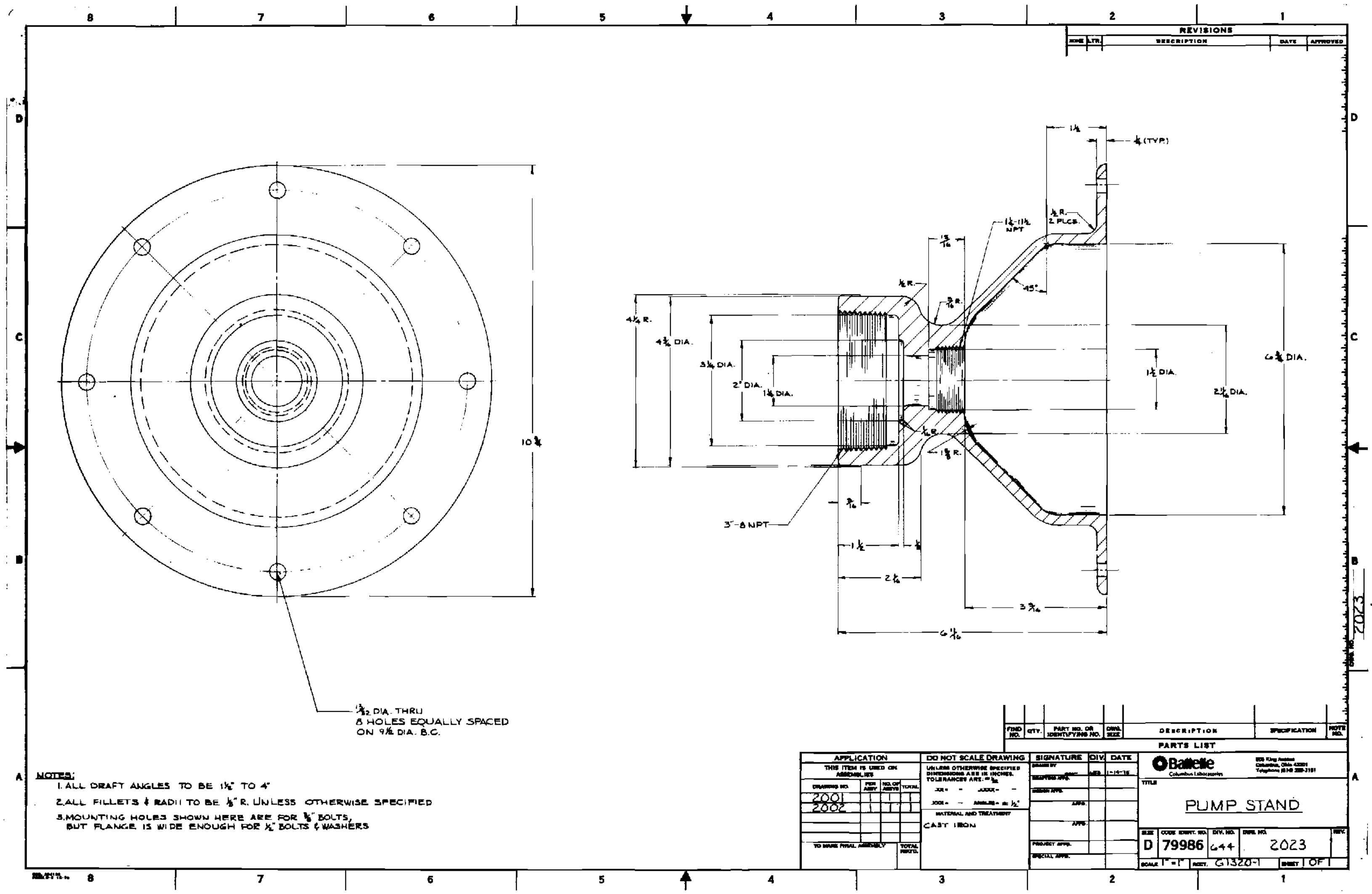
TITLE

CHECK VALVE WEIGHT

SIZE	CODE IDENT. NO.	DIV. NO.	DWG. NO.	REV.
A	79986	644	2022	

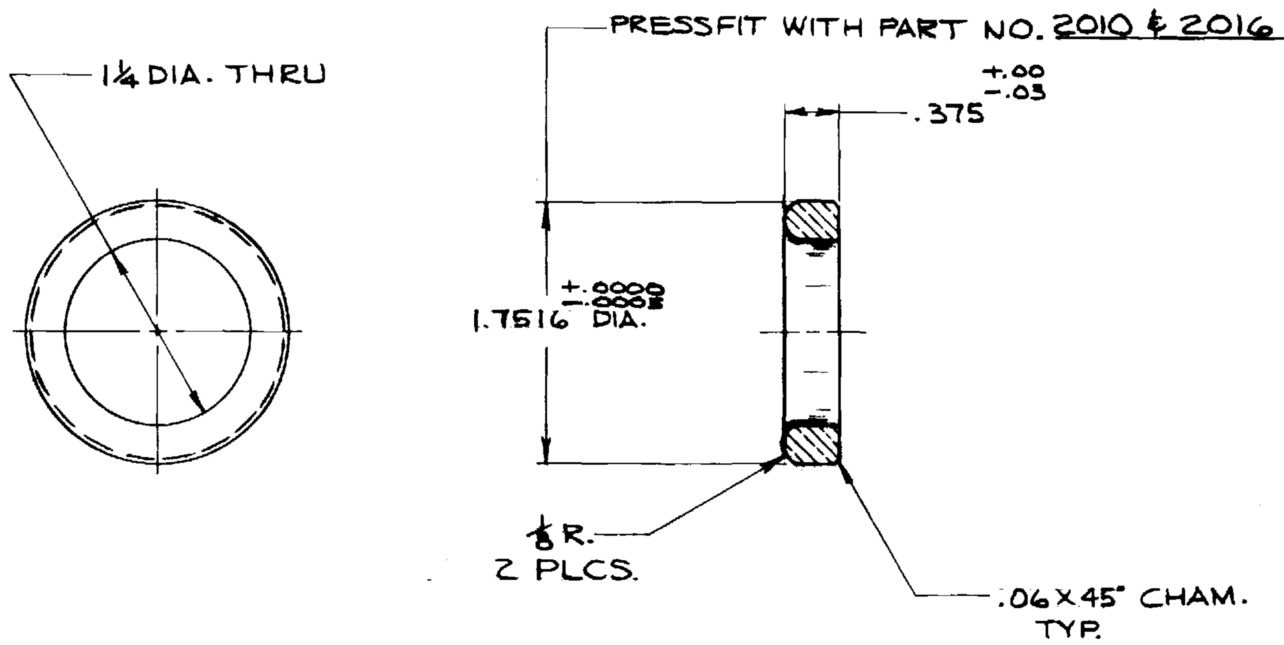
SCALE 1" = 1" ACCT G1320-1 SHEET 1 OF 1

CAT. 204163 FORM D-5 5-70



REVISIONS
ZONE LTR. DESCRIPTION DATE APPROVED
10¾
1/32 DIA. THRU
8 HOLES EQUALLY SPACED
ON 9⅛ DIA. B.C.
4¼ R.
4¾ DIA.
3¼ DIA.
2" DIA.
1⅜ DIA.
3"-8 NPT
1½
2⅛
6 1/16
3 3/4
1½ DIA.
2½ DIA.
6¾ DIA.
45°
1½-11½ NPT
½ R. 2 PLCS.
¼ (TYP)
NOTES:
1. ALL DRAFT ANGLES TO BE 1½° TO 4°
2. ALL FILLETS & RADII TO BE ⅛" R. UNLESS OTHERWISE SPECIFIED
3. MOUNTING HOLES SHOWN HERE ARE FOR ⅜" BOLTS, BUT FLANGE IS WIDE ENOUGH FOR ½" BOLTS & WASHERS
FIND NO. QTY. PART NO. OR IDENTIFYING NO. DWG. SIZE DESCRIPTION SPECIFICATION NOTE NO.
PARTS LIST
APPLICATION
THIS ITEM IS USED ON ASSEMBLIES
DRAWING NO. PER ASSY NO. OF ASSYS TOTAL
2001
2002
TO MAKE FINAL ASSEMBLY
TOTAL REQ'D.
DO NOT SCALE DRAWING
UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES. TOLERANCES ARE: ± 1/32
MATERIAL AND TREATMENT
CAST IRON
SIGNATURE DIV. DATE
DRAWN BY
1-14-76
DRAFTING APPR.
DESIGN APPR.
APPR.
APPR.
PROJECT APPR.
SPECIAL APPR.
Battelle
Columbus Laboratories
TITLE
PUMP STAND
SIZE D
CODE IDENT. NO. 79986
DIV. NO. 644
DWG. NO. 2023
SCALE 1" = 1"
ACCT. G1320-1
SHEET OF
DWG. NO. 2023

REVISIONS			
LTR	DESCRIPTION	DATE	APPROVED



APPLICATION			
THIS ITEM IS USED ON SUBASSEMBLIES			
DRAWING NO.	PER ASSY	NO. OF ASSYS	TOTAL
2010	1	1	1
2016	1	1	1
TO MAKE FINAL ASSEMBLY			TOTAL REQ'D.

DO NOT SCALE DRAWING

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES. TOLERANCES ARE: ± 1/32

.XX = ±.01 .XXXX = –

.XXX = – ANGLES = ± ½°

MATERIAL & TREATMENT

BRASS

SIGNATURE	DIV.	DATE
DRAWN BY	659	1-7-75
DRAFTING APPD.		
DESIGN APPD.		
APPD.		
PROJECT APPD.		
SPECIAL APPD.		

BATTELLE MEMORIAL INSTITUTE
COLUMBUS LABORATORIES
505 KING AVE., COLUMBUS, OHIO 43201

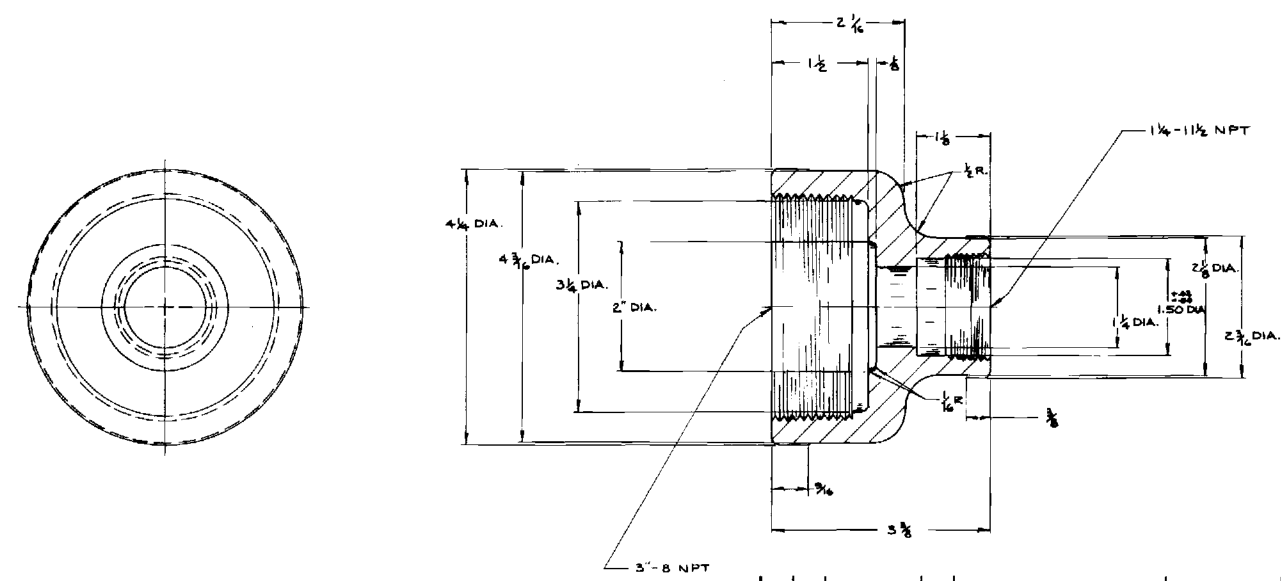
TITLE

BRASS
VALVE SEAT

SIZE	CODE IDENT. NO.	DIV. NO.	DWG. NO.	REV.
A	79986	644	2024	

SCALE 1" = 1" ACCT. G 1320-1 SHEET 1 OF 1

CAT. 394163 FORM D-8 5-70



NOTES:

1. ALL DRAFT ANGLES TO BE 1 1/2° TO 4°
2. ALL FILLETS & RADII TO BE 1/8" R. UNLESS OTHERWISE SPECIFIED

FIND NO.	QTY.	PART NO. OR IDENTIFYING NO.	DWG. SIZE	DESCRIPTION	SPECIFICATION	NOTE NO.

PARTS LIST

APPLICATION			
THIS ITEM IS USED ON SUBASSEMBLIES			
DRAWING NO.	PER ASSY	NO. OF ASSYS	TOTAL
2016	1	1	1
2002	1	1	1
2001"B"	1	1	1
TO MAKE FINAL ASSEMBLY			TOTAL REQ'D.

DO NOT SCALE DRAWING

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES. TOLERANCES ARE: ± 1/64

.XX = — .XXXX = —

.XXX = — ANGLES = ± 1/2°

MATERIAL AND TREATMENT

CAST IRON

SIGNATURE	DIV.	DATE
DRAWN BY	459	1-10-78
DRAFTING APPD.		
DESIGN APPD.		
APPD.		
APPD.		
PROJECT APPD.		
SPECIAL APPD.		

Battelle
Columbus Laboratories

505 King Avenue
Columbus, Ohio 43201
Telephone (614) 299-3151

TITLE

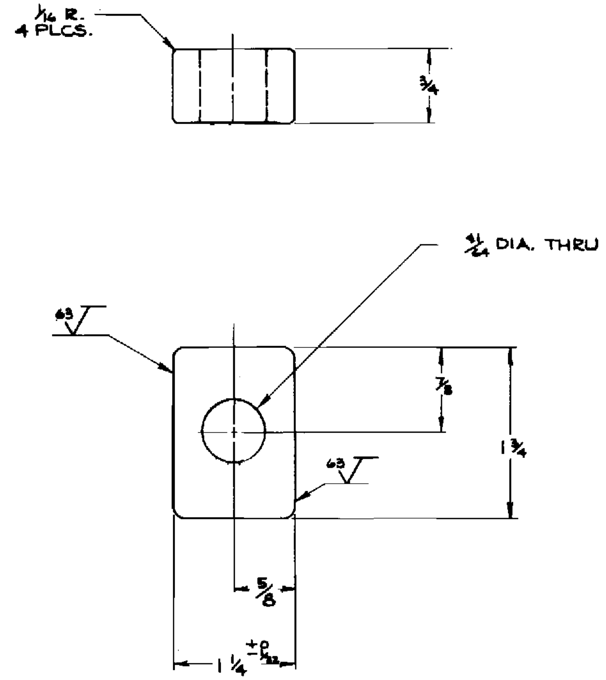
CYLINDER END CAP

SIZE	CODE IDENT. NO.	DIV. NO.	DWG. NO.	REV.
C	79986	644	2025	

SCALE 1"=1" ACCT. G1320-1 SHEET 1 OF 1

DWG. NO. 2025

CAT. 594197 FORM D-8 12-73



NOTES:

1. ALL DRAFT ANGLES TO BE 1½° TO 4°
2. ALL FILLETS & RADII TO BE 1/8" R. UNLESS OTHERWISE SPECIFIED

REVISIONS				
ZONE	LTR	DESCRIPTION	DATE	APPROVED

FIND NO.	QTY.	PART NO. OR IDENTIFYING NO.	DWG. SIZE	DESCRIPTION	SPECIFICATION	NOTE NO.

PARTS LIST

APPLICATION			
THIS ITEM IS USED ON SUBASSEMBLIES			
DRAWING NO.	PER ASSY	NO. OF ASSYS	TOTAL
2001	2	1	2
2002	2	1	2
TO MAKE FINAL ASSEMBLY			TOTAL REQ'D.

DO NOT SCALE DRAWING

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES. TOLERANCES ARE: ± 1/32

.XX = – .XXXX = –
.XXX = – ANGLES = –

MATERIAL & TREATMENT: CAST IRON

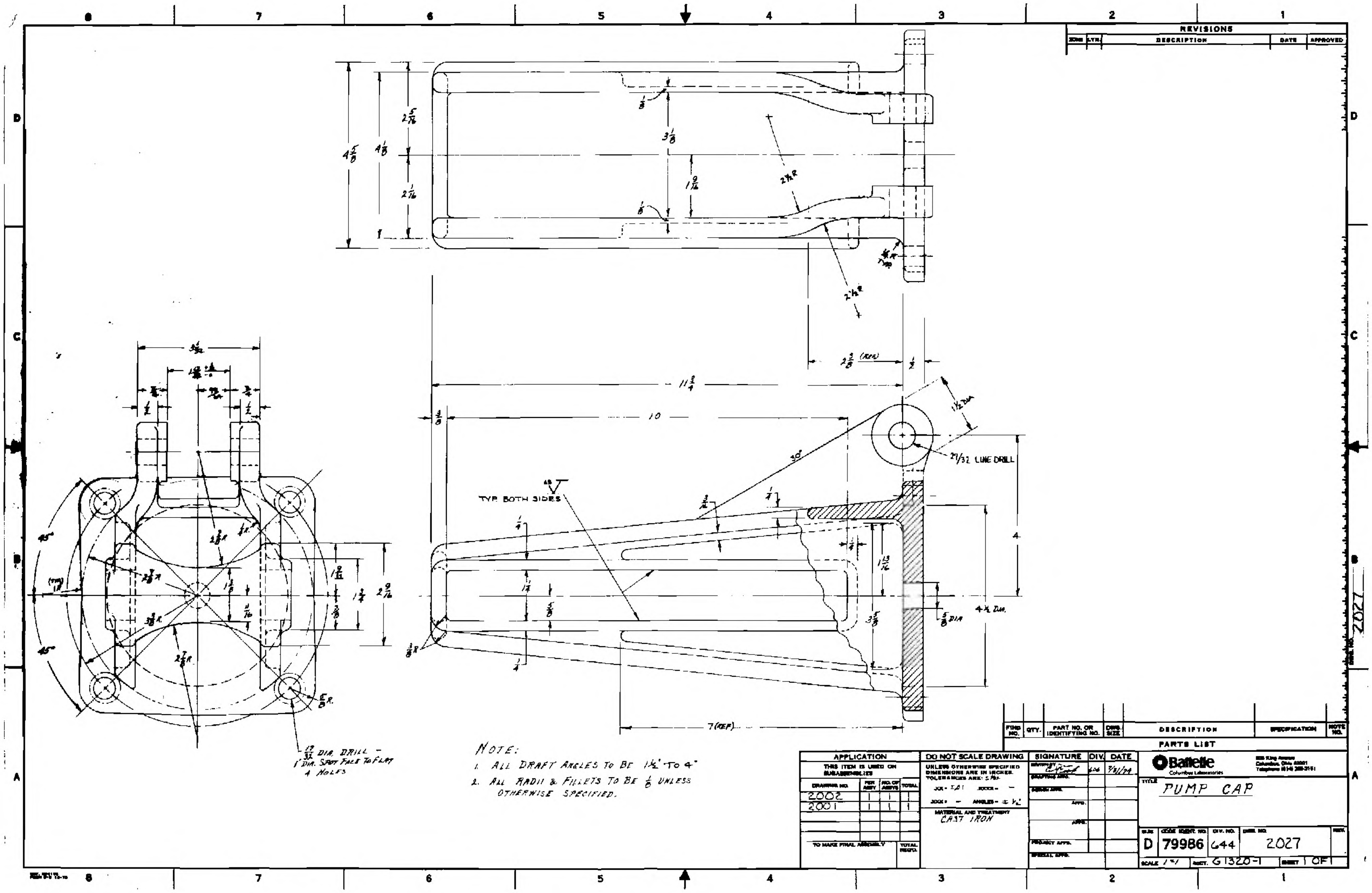
SIGNATURE	DIV.	DATE
DRAWN BY	653	1-8-75
DRAFTING APPD.		
DESIGN APPD.		
APPD.		
PROJECT APPD.		
SPECIAL APPD.		

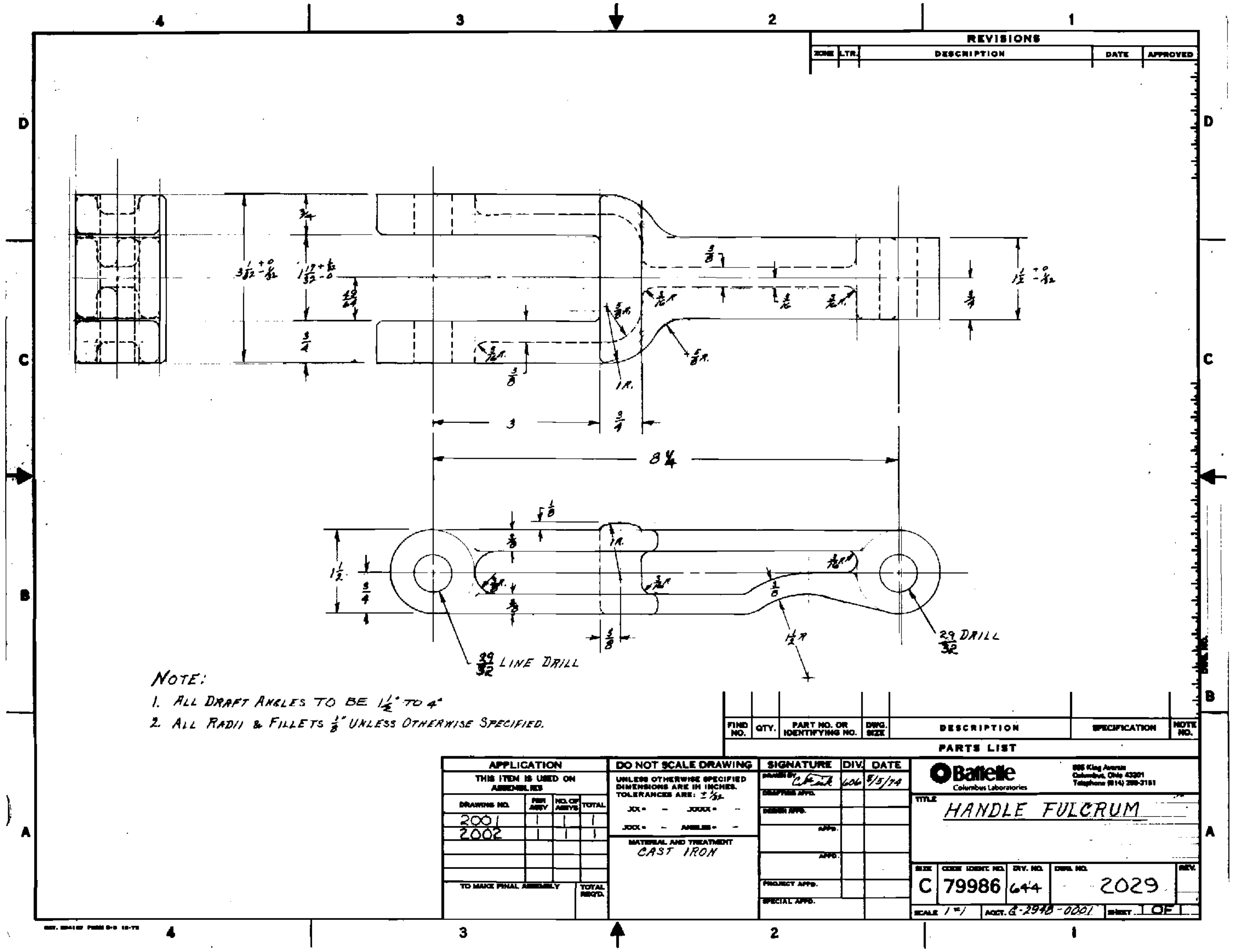
Battelle Columbus Laboratories
505 King Avenue
Columbus, Ohio 43201
Telephone (614) 299-3151

TITLE: SLIDING BLOCK

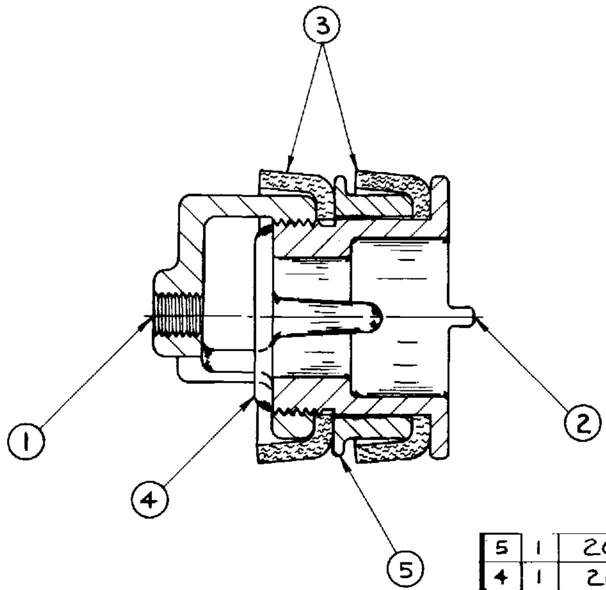
SIZE	CODE IDENT. NO.	DIV. NO.	DWG. NO.	REV.
B	79986	644	2026	

SCALE 1"=1" ACCT. G1320-1 SHEET 1 OF 1


REVISIONS
TYP BOTH SIDES
21/32 LINE DRILL
4¼ DIA.
5/8 DIA
7(REF)
17/32 DIA. DRILL - 1 DIA. SPOT FACE TO FLAT 4 HOLES
NOTE:
1. ALL DRAFT ANGLES TO BE 1½° TO 4°
2. ALL RADII & FILLETS TO BE 1/8 UNLESS OTHERWISE SPECIFIED.
PARTS LIST
APPLICATION
DO NOT SCALE DRAWING
UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES.
MATERIAL AND TREATMENT
CAST IRON
Battelle
Columbus Laboratories
PUMP CAP
D 79986 644 2027
G1320-1
1 OF 1


REVISIONS
ZONE LTR. DESCRIPTION DATE APPROVED
8 1/4
3
3/4
29/32 LINE DRILL
29/32 DRILL
NOTE:
1. ALL DRAFT ANGLES TO BE 1 1/2° TO 4°
2. ALL RADII & FILLETS 1/8" UNLESS OTHERWISE SPECIFIED.
FIND NO. QTY. PART NO. OR IDENTIFYING NO. DWG. SIZE DESCRIPTION SPECIFICATION NOTE NO.
PARTS LIST
APPLICATION
THIS ITEM IS USED ON ASSEMBLIES
DRAWING NO. PER ASSY NO. OF ASSYS TOTAL
2001 1 1 1
2002 1 1 1
TO MAKE FINAL ASSEMBLY TOTAL REQ'D.
DO NOT SCALE DRAWING
UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES. TOLERANCES ARE: ± 1/32
MATERIAL AND TREATMENT
CAST IRON
SIGNATURE DIV. DATE
606 8/5/74
DRAFTING APPD.
DESIGN APPD.
APPD.
APPD.
PROJECT APPD.
SPECIAL APPD.
Battelle
Columbus Laboratories
TITLE
HANDLE FULCRUM
SIZE C
CODE IDENT. NO. 79986
DIV. NO. 644
DWG. NO. 2029
REV.
SCALE 1=1
ACCT. G-2948-0001
SHEET 1 OF 1

REVISIONS				
ZONE	LTR	DESCRIPTION	DATE	APPROVED



NOTE:

1. DOUBLE CUP PLUNGER TO BE USED WHEN WATER LEVEL IS MORE THAN 50 FT. BELOW SURFACE

FIND NO.	QTY.	PART NO. OR IDENTIFYING NO.	DWG. SIZE	DESCRIPTION	SPECIFICATION	NOTE NO.
5	1	2032	A	PLUNGER SPACER		
4	1	2018	A	PLUNGER POPPET		
3	2	2019	A	THREE INCH CUP		
2	1	2031	B	PLUNGER FOLLOWER		
1	1	2017	B	PLUNGER CAGE		

PARTS LIST

APPLICATION			
THIS ITEM IS USED ON ASSEMBLIES			
DRAWING NO.	PER ASSY	NO. OF ASSYS	TOTAL
2001	1		
2002	1		
TO MAKE FINAL ASSEMBLY			TOTAL REQ'D.

DO NOT SCALE DRAWING

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES. TOLERANCES ARE:

.XX = .XXXX =
.XXX = ANGLES =

MATERIAL & TREATMENT

SIGNATURE	DIV.	DATE
DRAWN BY	644	1-10-76
DRAFTING APPD.		
DESIGN APPD.		
APPD.		
PROJECT APPD.		
SPECIAL APPD.		

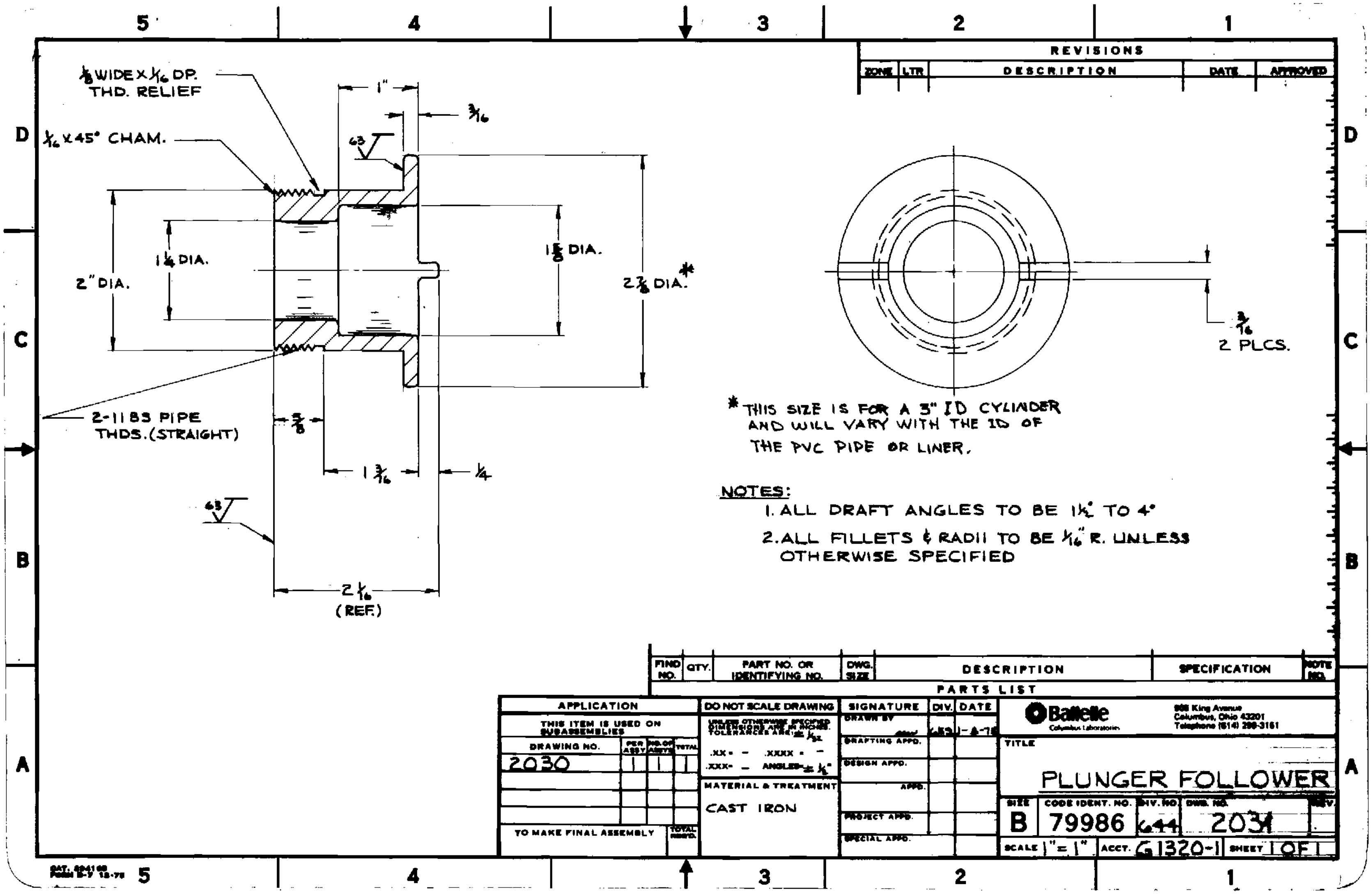
Battelle
Columbus Laboratories
505 King Avenue
Columbus, Ohio 43201
Telephone (614) 299-3151

TITLE PLUNGER ASSEMBLY, DOUBLE CUP

SIZE	CODE IDENT. NO.	DIV. NO.	DWG. NO.	REV.
B	79986	644	2030	

SCALE " = " ACCT. SHEET 1 OF 1

CAT. 294105 FORM D-7 12-73



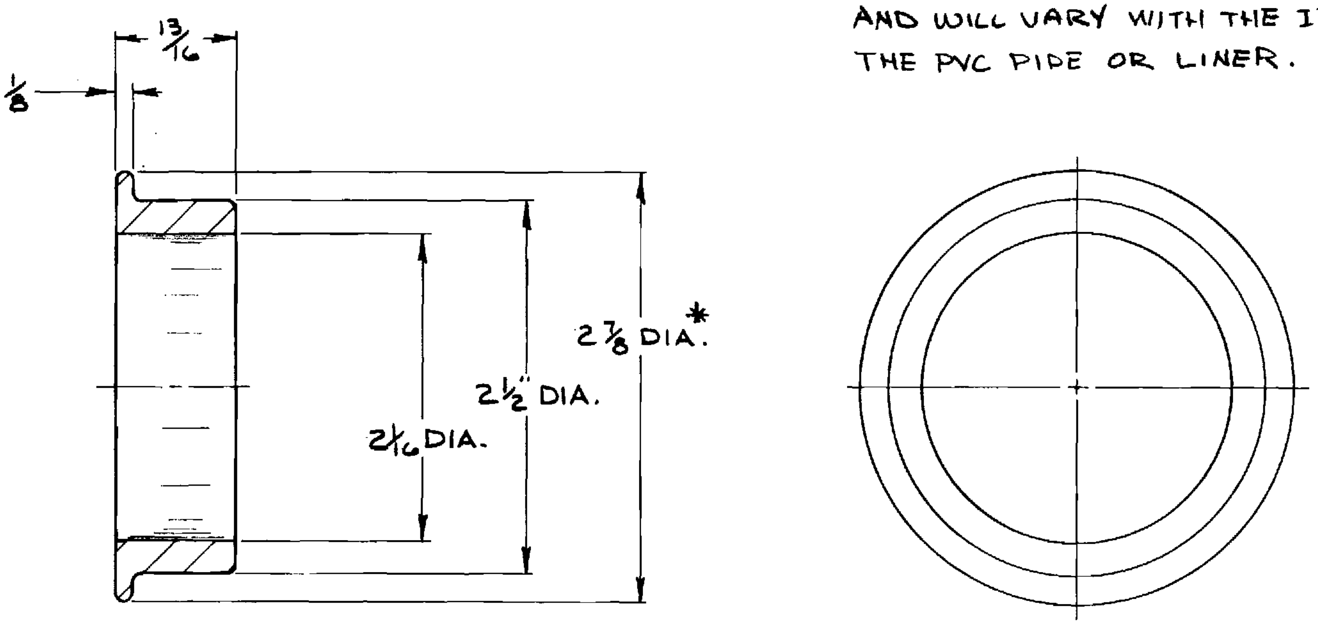
1/8 WIDE X 1/16 DP. THD. RELIEF
1/16 X 45° CHAM.
1"
3/16
63
2" DIA.
1 1/4 DIA.
1 5/8 DIA.
2 7/8 DIA.*
2-11 BS PIPE THDS.(STRAIGHT)
5/8
1 3/16
1/4
63
2 1/16 (REF.)
3/16 2 PLCS.
* THIS SIZE IS FOR A 3" ID CYLINDER AND WILL VARY WITH THE ID OF THE PVC PIPE OR LINER.
NOTES:
1. ALL DRAFT ANGLES TO BE 1 1/2° TO 4°
2. ALL FILLETS & RADII TO BE 1/16" R. UNLESS OTHERWISE SPECIFIED
REVISIONS
ZONE LTR DESCRIPTION DATE APPROVED
FIND NO. QTY. PART NO. OR IDENTIFYING NO. DWG. SIZE DESCRIPTION SPECIFICATION NOTE NO.
PARTS LIST
APPLICATION
THIS ITEM IS USED ON SUBASSEMBLIES
DRAWING NO.
2030
TO MAKE FINAL ASSEMBLY
DO NOT SCALE DRAWING
MATERIAL & TREATMENT
CAST IRON
SIGNATURE DIV. DATE
Battelle
Columbus Laboratories
TITLE
PLUNGER FOLLOWER
SIZE B
CODE IDENT. NO. 79986
DIV. NO. 644
DWG. NO. 2031
SCALE 1" = 1"
ACCT. G1320-1
SHEET 1 OF 1

NOTES:

1. ALL DRAFT ANGLES TO BE 1½° TO 4°
2. ALL FILLETS & RADII TO BE ⅛" R. UNLESS OTHERWISE SPECIFIED

REVISIONS			
LTR	DESCRIPTION	DATE	APPROVED

* THIS SIZE IS FOR A 3" ID CYLINDER AND WILL VARY WITH THE ID OF THE PVC PIPE OR LINER.



APPLICATION			
THIS ITEM IS USED ON SUBASSEMBLIES			
DRAWING NO.	PER ASSY	NO. OF ASSYS	TOTAL
2030	1	1	1
TO MAKE FINAL ASSEMBLY			TOTAL REQ'D.

DO NOT SCALE DRAWING

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES. TOLERANCES ARE: ± 1/32

.XX = – .XXXX = –
.XXX = – ANGLES = –

MATERIAL & TREATMENT: CAST IRON

SIGNATURE	DIV.	DATE
DRAWN BY gew	659	1-7-78
DRAFTING APPD.		
DESIGN APPD.		
APPD.		
PROJECT APPD.		
SPECIAL APPD.		

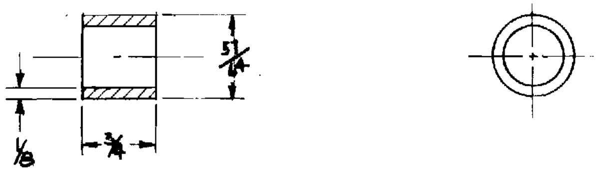
BATTELLE MEMORIAL INSTITUTE
COLUMBUS LABORATORIES
505 KING AVE., COLUMBUS, OHIO 43201

TITLE: PLUNGER SPACER

SIZE	CODE IDENT. NO.	DIV. NO.	DWG. NO.	REV.
A	79986	644	2032	

SCALE 1"=1" ACCT G1320-1 SHEET 1 OF 1

CAT. 294163 FORM D-5 5-70



HARDEN TO R_c 60-65

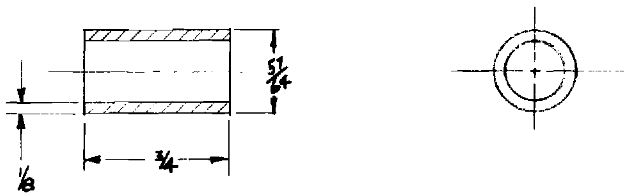
APPLICATION —

DRAWING NO.	PER ASSY.	NO. OF ASSYS.	TOTAL
2008	2	1	2
2026	1	2	2
2027	2	1	2
2029	2	1	2

OFFICE OF INTERNATIONAL PROGRAMS
ENGINEERING EXPERIMENT STATION
GEORGIA INSTITUTE OF TECHNOLOGY
ATLANTA, GEORGIA 30332

TITLE SHORT BUSHING — STEEL

DRAWN BY G.K. WEBB DATE 1/17/79	APPROVED BY K. C. Moh DATE 1/17/79	REVISION NO. 1 BY DATE	REVISION NO. 2 BY DATE
SCALE 1" = 1"	PROJECT NO.		SHEET 2033



HARDEN TO R_c 60-65

APPLICATION-	DRAWING NO.	PER ASSY.	NO. OF ASSYS.	TOTAL
	2004	1	1	1
	2008	1	1	1
	2029	1	1	1

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ENGINEERING EXPERIMENT STATION
GEORGIA INSTITUTE OF TECHNOLOGY
ATLANTA, GEORGIA 30332

TITLE LONG BUSHING - STEEL			
DRAWN BY G.K. WEBB DATE 1/17/79	APPROVED BY K. C. Moh DATE 1/17/79	REVISION NO. 1 BY DATE	REVISION NO. 2 BY DATE
SCALE 1" = 1"	PROJECT NO.	SHEET 2034	